OCTOBER 1954

Journal

VOL. 46 • NO. 10

AMERICAN WATER WORKS ASSOCIATION

Two Parts
PART 1:

Part 2 is AWWA Directory

Cavitation Control	Kunigk
Forecasting City Population	Schmitt, Elder
Reclamation Area Water Systems	Howland
Revenue Bond Survey	Francis, Grayson
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Oil Pipeline Failures	Cunningham, Detweiler, Hatcher, API
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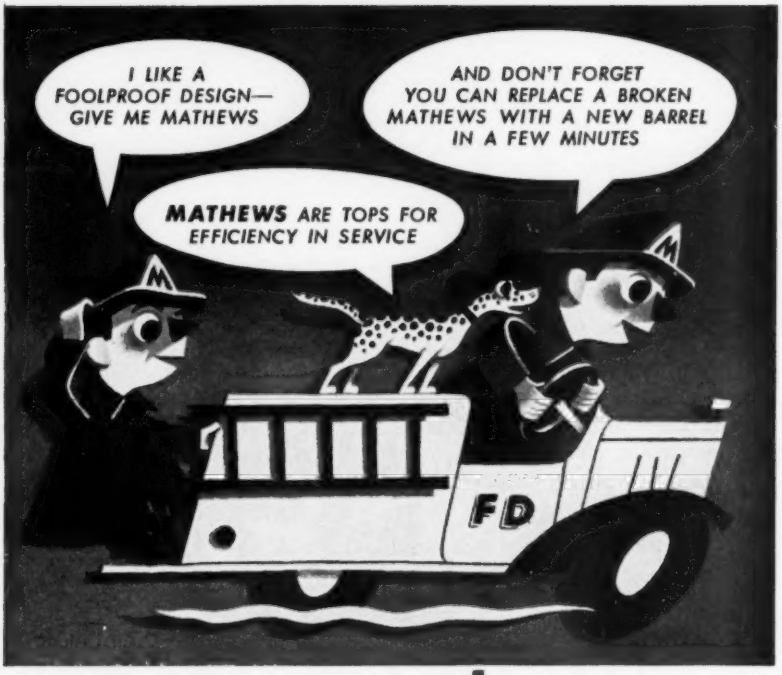
Specifications for Cement-Mortar Lining in Place	AWWA C602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Journal

AMERICAN WATER WORKS ASSOCIATION

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AWWA Directory

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Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 521 Fifth Ave., New York 17, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. $7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to non-members—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

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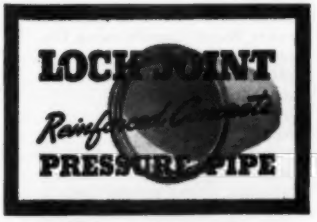

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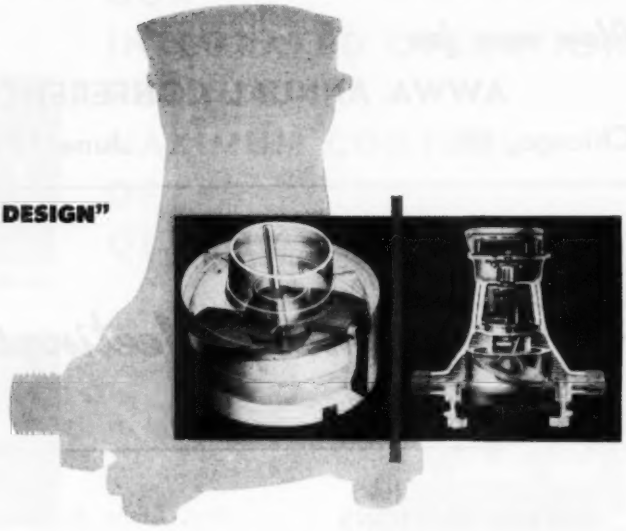
MEANS



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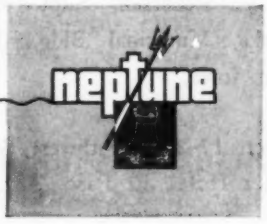

Plan now for

AWWA ANNUAL CONFERENCE

Chicago, Ill. June 12-17, 1955

Coming Meetings

AWWA SECTIONS

October 4–5—Maritime Branch, Canadian Section at Hotel Brunswick, Moncton, New Brunswick. Secretary, J. D. Kline, P.O. Box 574, Halifax, N.S.

Oct. 6–8—Minnesota Section at Lowry Hotel, St. Paul. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Oct. 13–15—Iowa Section at Hotel Roosevelt, Cedar Rapids. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

Oct. 17–20—Southwest Section at Cortez Hotel, El Paso, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 24–27—Alabama-Mississippi Section at Tutwiler Hotel, Birmingham, Ala. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Oct. 26–29—California Section at Wilton Hotel, Long Beach. Secretary, Henry Franklin Jerauld, Asst. Supt. of Constr. & Operation, Water Dept., 1040 Manzanita, Pasadena 3, Calif.

Oct. 27–29—Chesapeake Section at Belvedere Sheraton Hotel, Baltimore,

(Continued on page 8)

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Coming Meetings

(Continued from page 6)

Md. Secretary, Carl J. Lauter, 6955 —33rd St., Washington 15, D.C.

Nov. 3–5—Virginia Section at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, 213 Carlton Terrace Bldg., Roanoke 11, Va.

Nov. 4–6—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan, Inc., Box 178, Newark 1, N.J.

Nov. 7–10—Florida Section at Soreno Hotel, St. Petersburg. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica-Burnett Chemical Co., Box 2328, Jacksonville, Fla.

Nov. 8–9—West Virginia Section at Prichard Hotel, Huntington. Secretary, H. K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston 5, W.Va.

Nov. 8–10—North Carolina Section at George Vanderbilt Hotel, Asheville. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh, N.C.

Nov. 9–10—Rocky Mountain Section at Broadmoor Hotel, Colorado Springs, Colo. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

Dec. 2–4—Cuban Section at Sociedad Cubana de Ingenieros, Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana, Cuba.

OTHER ORGANIZATIONS

Oct. 3–6—New England Water Works Assn., Poland Springs, Me.

Oct. 11–14—Federation of Sewage & Industrial Wastes Assns., in Cincinnati.

Oct. 11–15—American Public Health Assn., in Buffalo

Oct. 17–20—American Society of Civil Engineers, in New York City

Oct. 19–21—Public Utilities Sessions, National Safety Congress, Chicago

Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 17–19—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York

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GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

SALES REPRESENTATIVES IN PRINCIPAL CITIES

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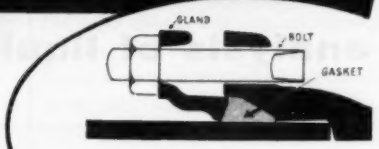
MECHANICAL JOINT PIPE WINS

WIDESPREAD APPROVAL



Boltite pipe is used for water, gas, steam, oil, chemicals and other liquids. Gaskets are rubber compound, asbestos, duck tipped, and other materials for special services.

The popularity of standardized mechanical joints for Cast Iron Pipe has increased so rapidly that now it is the leading type joint used for water, gas, chemicals, steam, oils and other liquids. It is widely adaptable to different services by using different type gaskets, including rubber compound, asbestos; duck, lead or thiokol tipped, etc. This type joint is furnished on pipe made to comply with different standards such as Federal, A. W. W. A. and A. S. A. specifications.

McWANE-PACIFIC

"BOLTITE"

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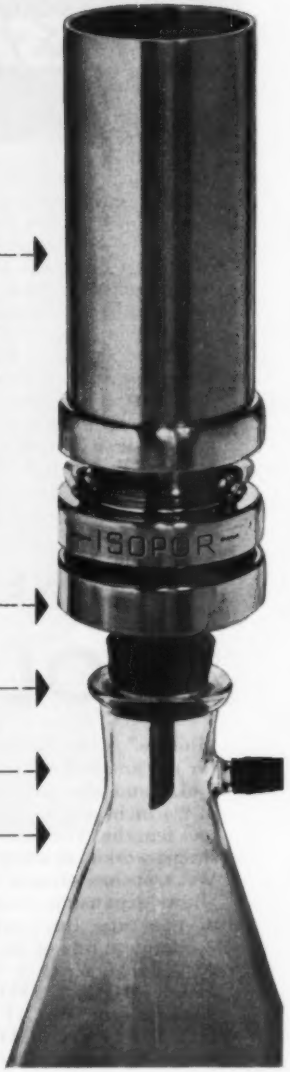
Molecular filter holder for bacteriological analysis of liquids



This new ISOPOR Holder for molecular filter membranes has been developed and perfected under the supervision of Dr. Alexander Goetz, international authority in the field of molecular membrane filtration. (J. Am. Waterworks Assoc., 43, 943-984 [1951]; 44, 471-483 [1952]; 45, 933-944, 1196-1210 [1953]; and others.)

Designed for maximum efficiency in either laboratory or field bacteriological analysis, this new ISOPOR MF Holder has many advantages over any other MF equipment previously available.

ADVANCED DESIGN—*The ISOPOR MF Holder is compact, efficient, easy to operate and sterilize. Overall height only 10¼", 500 ml capacity.*

STAINLESS STEEL CONSTRUCTION *eliminates corrosion, breakage, and necessity for gaskets which deteriorate under heat and with age.*

AUTOMATIC ADJUSTMENT—*Unique construction eliminates danger of damaging pressure on the MF membrane.*

STERILIZABILITY—*The ISOPOR MF Holder is not subject to autoclave damage. In addition, it is equipped for formaldehyde sterilization by the incomplete combustion of methyl alcohol, as described in literature (above).*

A G CHEMICAL COMPANY, INC.

P. O. Box 65C • Pasadena, California

FOR FIXED LABORATORIES

The ISOPOR MF Holder reduces time and expense in hydrosol analysis. No dilution necessary in most cases, high reliability of results, and MF membrane becomes permanent record. Using ISOPOR dehydrated nutrient schedules, standard tests can be completed in 16–18 hours without intermediate operations, using only two pieces of sterile equipment.

FOR FIELD ANALYSIS

The ISOPOR Water Laboratory, of which the ISOPOR MF Holder is a component, makes possible the performance of bacteriological water analysis in the field, away from laboratory facilities and independent of utilities (water, power, gas), with only one item of expendable supply (ISOPOR dehydrated nutrient schedules). The ISOPOR Water Laboratory is easily portable (only about 30 lbs. complete), contains *all* facilities and equipment for 24 independent hydrosol tests.

MAIL THIS COUPON FOR FURTHER INFORMATION

AG CHEMICAL COMPANY, INC.

Box 65C • Pasadena, California

Please send me further information and literature on

☐ ISOPOR MF Holder ☐ ISOPOR Water Laboratory

☐ ISOPOR Sterile Dehydrated Nutrient Packs

Name_____

Organization_____

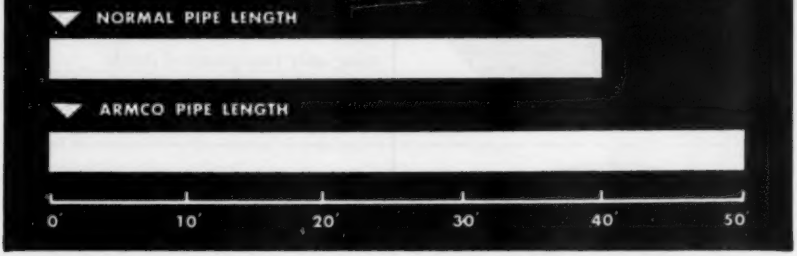
Street Address_____ City_____ State_____

Patents Pending

See ISOPOR Ad on Page 93.

"King Size" Pipe

Filters Out High Labor Costs

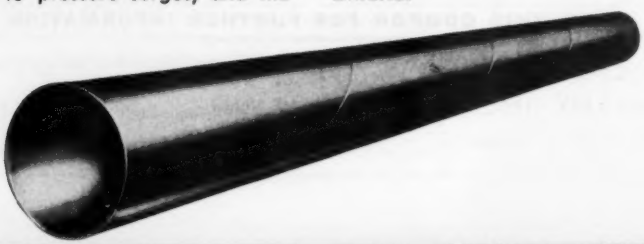


Think of the advantages of using the longer 50-foot sections of Armco Welded Steel Pipe compared to the usual 40-foot lengths. There are fewer sections to haul and handle and 20% fewer joints to make. Labor costs are reduced and installation goes faster.

The wide range of diameters (6 to 36 inches) and wall thicknesses (9/64- to 1/2-inch) makes it easy to match pipe requirements exactly.

Other features of Armco Pipe include ample strength plus ductility, resistance to pressure surges, and the ability to withstand impact of heavy loads without damage. A spun-enamel lining prevents tuberculation. Coatings are supplied to meet A.W.W.A. specifications.

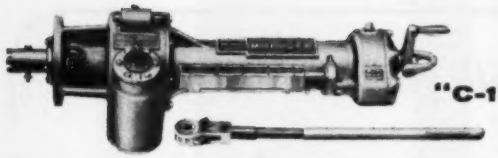
Let Armco Welded Steel Pipe help cut costs of supply lines, force mains or water works piping. Write for complete data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2834 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.



ARMCO WELDED STEEL PIPE

MEETS A.W.W.A. SPECIFICATIONS

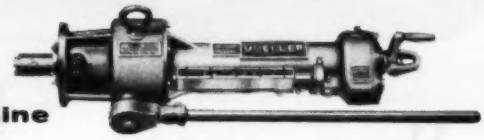
ARMCO



"C-1" Drilling Machine

MUELLER

Proven Design Gives Versatility



"CC" Drilling Machine

Install needed valves and connect branch mains, under pressure, with a Mueller "CC" or "C-1" Drilling Machine!

Versatility has been carefully designed into the "CC" and "C-1", permitting their use with Mueller Inserting Valves, Tapping Sleeves and Valves, Gate Valves and special fittings to perform a wide variety of water works operations.

Both machines are similar in design and construction except that the "CC" is hand operated and the "C-1" is power operated by an air motor or portable gasoline engine drive unit. They constitute part of a complete line of drilling and tapping machines designed to meet your every need..

Consult your Mueller Representative or write direct for complete information.

SPECIFICATIONS

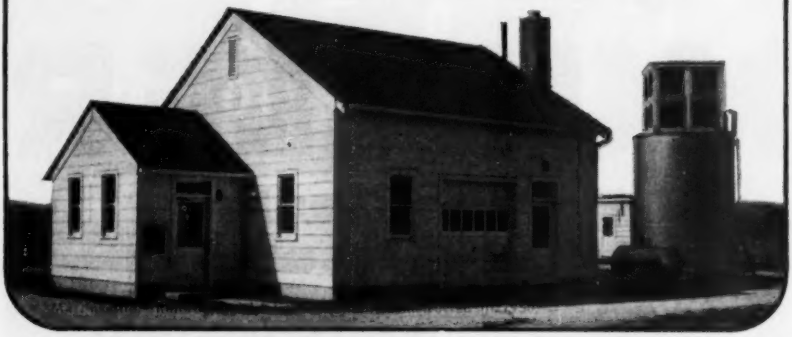
Makes cuts 2″ through 12″
500 psi maximum working pressure at 100°F.
500°F. maximum temperature rating at 250 psi
25″ boring bar travel
Automatic or manual feed
Feed indicator standard equipment

MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS

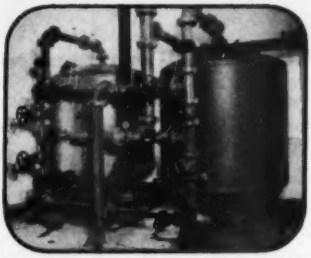
How Martinsville gets iron-free, soft water



Martinsville, Illinois Municipal Water Plant

Martinsville's untreated well water was a wasteful nuisance!

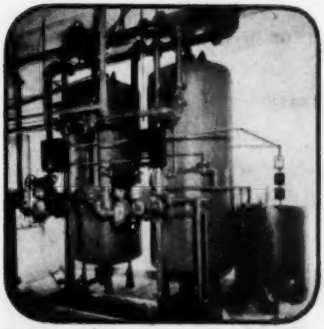
Its 269 ppm of total hardness ruinously scaled pipes . . . annoyed citizens by wasting soap, leaving rings around bathtubs, sticky curd on dishes, laundry. Iron of 2 ppm gave it an unpleasant metallic taste, stained laundry.



Compact Permutit pressure filters have a 150 gpm capacity...remove iron oxidized in coke-tray aerator, reduce turbidity.

These troubles were ended when Martinsville installed the Permutit equipment shown. On a recent check, we asked for the operator's opinion of our equipment.

Mr. O. Wiser—who is in charge of this plant—reports: "The Permutit equipment is very good . . . has worked very well with very little maintenance."



Permutit softeners remove hardness, further reduce iron to 0.02 ppm! Automatic regeneration saves time . . . provides constant supply of softened water.

Free Technical Bulletins

Write today for full information on any water conditioning process or problem. THE PERMUTIT COMPANY, Dept. JA-10 330 West 42nd Street, New York 36, N. Y.

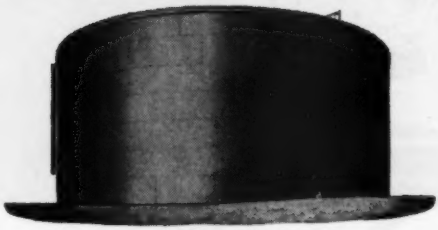
Water Conditioning Headquarters For Over 40 Years

PERMUTIT®

2 million Gallons

1½ million Gallons

HAMMOND Standpipes . . . Designed to Harmonize with Surroundings.



5 million Gallons

HAMMOND Steel Reservoirs . . . . . Efficient and Economical

when located on ground sufficiently high to produce required gravity pressure —Illustrated is a Hammond five million Gallon Steel Reservoir.

HAMMOND WATER STORAGE TANKS

By the very nature of water supply service, storage tank integrity of design and soundness of construction are absolutely essential.

For more than half a century Hammond has been incorporating these characteristics in all its products — Steel Standpipes • Steel Reservoirs • Elevated Water Tanks • Water Spheres • Filtration and Purification Units for general water supply and fire protection systems.

Hammond Water Storing and Processing Vessels are built to all standard codes and specifications including those of the American Water Works Association, Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, the Factory Insurance Association.

400,000 Gallons

500,000 Gallons

150,000 Gallons

100,000 Gallons

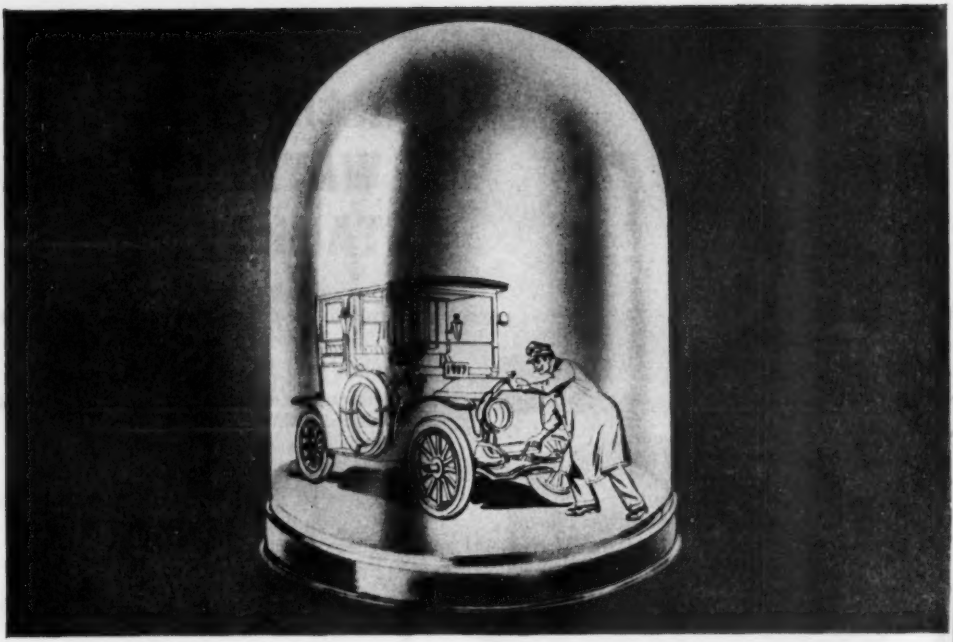
HAMMOND Elevated Tanks . . . Double Ellipsoidal, Cone Roof, Radial Cone Bottom and Sphere . . . from 25,000 to 3,000,000 gallon capacity.

Catalog H_2O details and describes all HAMMOND Water Storage and Processing Vessels... Write for your copy.

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices: NEW YORK 20 • AKRON • BOSTON 10 • BUFFALO 2 • CHICAGO 3 • CINCINNATI 2 • CLEVELAND 15 • EL PASO • HOUSTON 2 • LOS ANGELES 14 • PITTSBURGH 19 RICHMOND 20 • SAN FRANCISCO • WASHINGTON 6, D.C. • HAVANA • "TIPSA" BUENOS AIRES



how much does it cost . . . to "crank" an old style chlorinator?

The automobile self-type starter isn't news any more — nobody ever cranks a car these days. "Cranking" an old-style chlorinator is equally out-dated.

The F&P mechanical, instrument-type chlorinator is sweeping the country, sales mount month by month. Why? Because municipality after municipality, consulting engineer after consulting engineer, reports the same facts: F&P chlorinators are lower in first cost, are easier to handle, because they are so simple in design, so light in weight, so modern in construction. More important, however, it is always stressed that F&P chlorinators require practically no maintenance, practically no spare parts.

We claim that if you are operating a chlorinator that has a bell jar on it *you need a new chlorinator.* You are "cranking" an old, costly, inefficient chlorinator. Everybody knows that dry chlorine is not corrosive—but that as soon as you put the chlorine in contact with water or water vapor it becomes corrosive. That's what the water tray types of chlorinators do—put dry, non-corrosive chlorine in contact with water and make corrosive vapor out of it. It's not engineering sense and the way to avoid it—and the resulting expensive maintenance — is to get F&P *mechanical, instrument type* chlorinators.

Don't refrain from writing us because you don't need additional chlorinating capacity right now. Moreover—if it is time for a major overhaul or a rebuilding of your bell jar chlorinator, let us quote you for doing this work. We will give you what you may not have gotten previously—a firm price for doing the job before we start on it. The price will be a reasonable one, but we'll also quote you a price for replacing the chlorinator and if you want to spread the cost of the new one by time payments or if you want a lease arrangement, you can have it. Chances are you cannot justify further overhaul or further rebuilding—even at our *fair* price for doing the work.

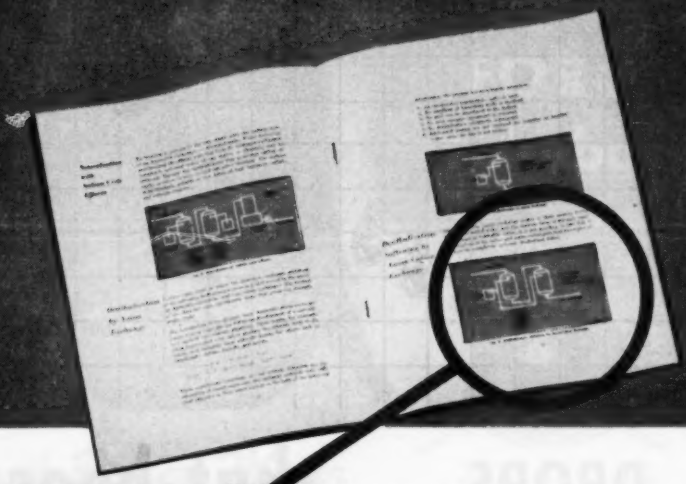
complete process instrumentation

FISCHER & PORTER CO.

1004 Fischer Road, Hatboro, Penna.

18 YEARS EXPERIENCE SUCCESSFULLY MANUFACTURING CHLORINE FLOW METERING EQUIPMENT

AMBERLITE ION EXCHANGE RESIN REDUCES ALKALINITY WITHOUT ACIDS OR DEGASIFIERS



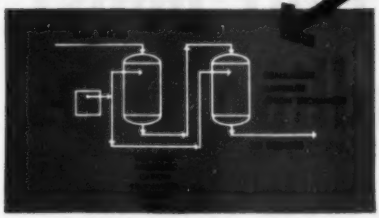


Fig. 6—Dealkalization-Softening by Anion-Cation Exchange

A strongly basic AMBERLITE anion exchange resin permits control of alkalinity of water supplies for boilers and cooling systems conveniently and at low cost. Only common salt is required as regenerant for the resin. No acids are used, hence expensive acid-resistant equipment and associated handling problems are eliminated. Because no degasifier is required, line pressure is not broken, and pumping costs are reduced.

New Book Gives Valuable Information on Water Treatment Problems

Rohm & Haas Company's new book, *If You Use Water*, discusses this up-to-date technique—and many other ion exchange methods of water treatment as well. Softening, combination softening-dealkalization, silica removal, deionization, are just some of the topics considered. Your request for this book will bring you a copy promptly, will show you why in ion exchange the resin that's *right* is AMBERLITE.

Send for your free copy of this book today

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

AMBERLITE is a trademark, Reg. U.S. Pat. Off. and in principal foreign countries.

ROHM & HAAS COMPANY
Washington Square, Philadelphia 5, Pa.

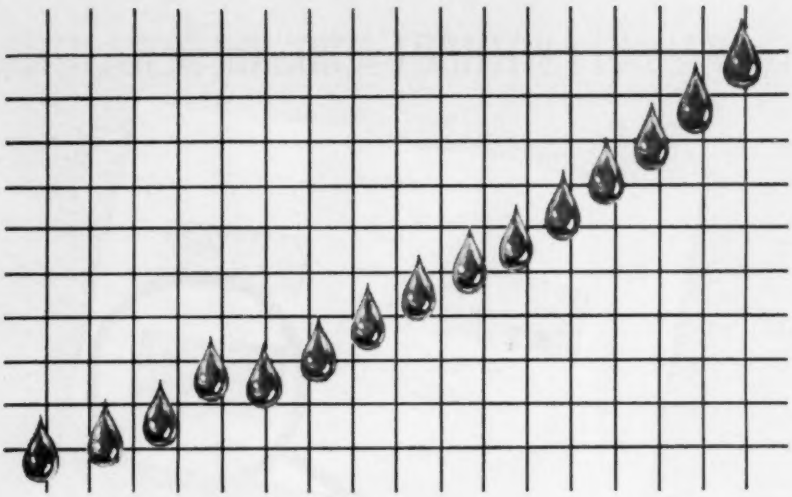
Please send me a copy of "If You Use Water..."

Name_____

Title_____

Address_____

City_____ Zone___ State_____



DROPS . . . that boost sewage handling costs

NEVER UNDERESTIMATE the extra load put on a sewage system by simple infiltration of soil water. Pumping costs jump . . . and disposal plant costs climb likewise.

INFILTRATION can be prevented with ATLAS JC-60,® the new plastic base sewer pipe jointing compound. JC-60 provides tight joints, strong as the pipe itself, that prevent unwanted soil water from entering your pipeline—or sewage from escaping.

Other characteristics of JC-60 provide resistant joints that positively stop root penetration—flexible joints that take normal settling without rupture . . . and numerous on-the-job advantages that speed sewer construction and reduce waste.

GET THE COMPLETE FACTS ON ATLAS JC-60
Write for Bulletin M20-3.

ATLAS JOINTING COMPOUNDS
. . . a permanent bond

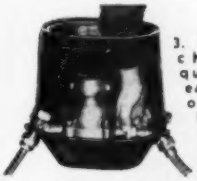
OTHER ATLAS PIPE JOINTING MATERIALS include GK® and SLIPJOINT GK® for sewers . . . Tegul MINERALEAD® and HYDRORINGS for cast iron water pipe.

ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN PENNSYLVANIA
HOUSTON 1, TEXAS

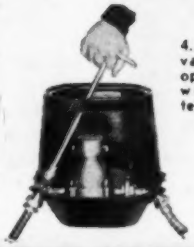
The **FORD Yokebox**

1. Small lid, clean meter, speeds meter reading.

2. Easy to handle, quickly installed as a unit.



3. Meter changes quick and easy, without cumbersome tools.



4. Service valve easily operated and well protected.

A Better Meter Setting for Shallow Services

A simple, compact meter housing, complete with service valve, for warm climate installations. The modern and better way to install water meters. Gives better protection, keeps meter cleaner. An investment in easier meter reading, longer meter life and greater revenue.

Write for information on the Yokebox.

FORD

FOR BETTER WATER SERVICES

THE FORD METER BOX COMPANY, INC. Wabash, Indiana

Pipe Line Equipment
WATER • GAS • SEWER

Bottled Gas Lead Melting Furnace

Asbestos Joint Runners

Best quality asbestos rope, brass caps attached to each end. Equipped with clamps.

M-D Cut-In Connections for Sewers

A light cast iron fitting with bell end for connecting house service with main sewer pipe without necessity for placing a Y-branch or T-branch in the sewer line.

Leak Detector

A truly fine instrument designed to solve even the most difficult leak detecting problem.

Calking Tool Outfit

For water mains up to 12". Strong leather bag. Keeps the right tool for every job within easy reach.

Test Plugs for Bell or Spigot End Cast Iron Pipe.

On this page are shown only a few of the hundreds of items to be found in the POLLARD Catalog. Write for a copy of Catalog No. 25K.

Portable Lead Melting Furnace

A handy outfit for quick action, equipped with gasoline burner.

Pipe Cutter

Inexpensive way of cutting pipe. Every wheel in contact with the pipe is a cutting disc, so cutter need be moved only a short distance to cut entirely around the pipe.

Tapax

The original manhole cushion. Takes the bang out of manhole covers.

M-Scope Pipe Finder

It's easy to locate a buried pipe line with this handy pipe finder.

JOSEPH G. POLLARD CO., INC.

Western Office
1064 Peoples Gas Bldg.
Chicago, Ill.

MAIN OFFICE AND FACTORY
New Hyde Park, N. Y.

Southern Office
333 Candler Bldg.
Atlanta, GA.

MH
LOOK FOR THIS MARK
OF QUALITY
ON VALVES AND
HYDRANTS
The widespread and fast-growing demand for M & H Valves, Hydrants and accessories is due primarily to outstanding superior quality in design, materials and workmanship. In the M & H double-disc gate valve, for example, the iron body and the bonnet flanges are heavily proportioned and unusually strong. The discs are held in alignment by guides and are seated or released by three-point action of bronze spreaders. The bronze seat rings are exceptionally heavy. Either disc may be used on the down-stream side. For additional information about the advantages of M & H Valves or Hydrants, write M & H VALVE and FITTINGS COMPANY, ANNISTON, ALABAMA.
M&H PRODUCTS
FOR WATER WORKS • FILTER PLANTS
INDUSTRY • SEWAGE DISPOSAL AND
FIRE PROTECTION

Reilly's **new** *Calculator*

You can't afford to be without this Reilly Coal Tar Base Enamel quantity calculator to serve as your handy portable guide. Complete with estimates for enamel requirements on two grades of Reilly Primer, the tables also furnish valuable information on coupling compounds, recommended temperatures for application and quantities required for hand application of Reilly Coal Tar Base Enamels.

Send for your Reilly Calculator today.

Reilly COAL TAR PRODUCTS

REILLY TAR & CHEMICAL CORPORATION

MERCHANTS BANK BUILDING

INDIANAPOLIS 4, INDIANA

TRY IT YOURSELF

the *New*

HAYS Model B

Aluminum Alloy Tapping Machine

The new HAYS Model B Tapping Machine, now made of High Strength aluminum alloy, is light, compact, efficient. The HAYS Machine takes up less room in the ditch, requires fewer operations, is easier to handle, easier to operate, speeds up installation of all standard makes of corporation stops.

Your HAYS distributor or our representative will be glad to demonstrate the Model B . . . or write us about one for a trial on the job by your own men.

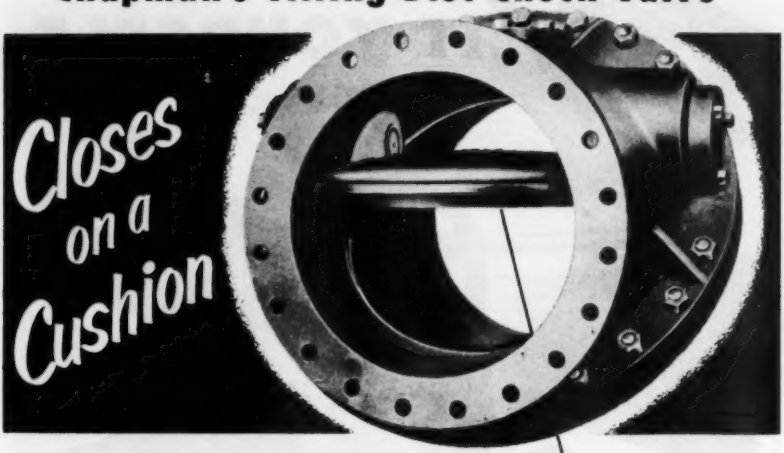
- Only 36 pounds to handle
- Rugged construction
- Fast and simple to operate
- Renewable bearing bronze feed yoke insert
- No disassembly to insert Corporation Stop
- Complete with chest

HAYS®

WATER WORKS PRODUCTS

HAYS MANUFACTURING CO.
ERIE, PA.

Chapman's Tilting Disc Check Valve

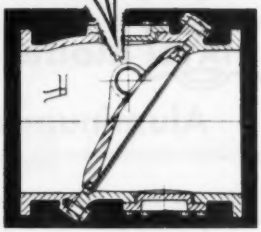


...for low cost, slam-free operation

Balanced pressures *cushion* the movement of the disc in Chapman's Tilting Disc Check Valve. The valve closes quickly but quietly, in all but unusual piping arrangements. There's no slamming to damage pipe-line joints or the valve itself. And *drop-tight* closure eliminates sliding wear on the disc and seat.

In the open position, the "airfoil" designed disc rides firmly against stops, without swinging or fluttering. That's why the hardened extra-large hinge pins give extremely long wear. And the absence of turbulence is one reason why head loss through Chapman's Tilting Disc Check Valve is lower than through any other type of check valve.

Low head loss, increased wear resistance and freedom from destructive slamming make Chapman's Tilting Disc Check Valves unbeatable for almost every installation. Write for Catalog No. 30 today.



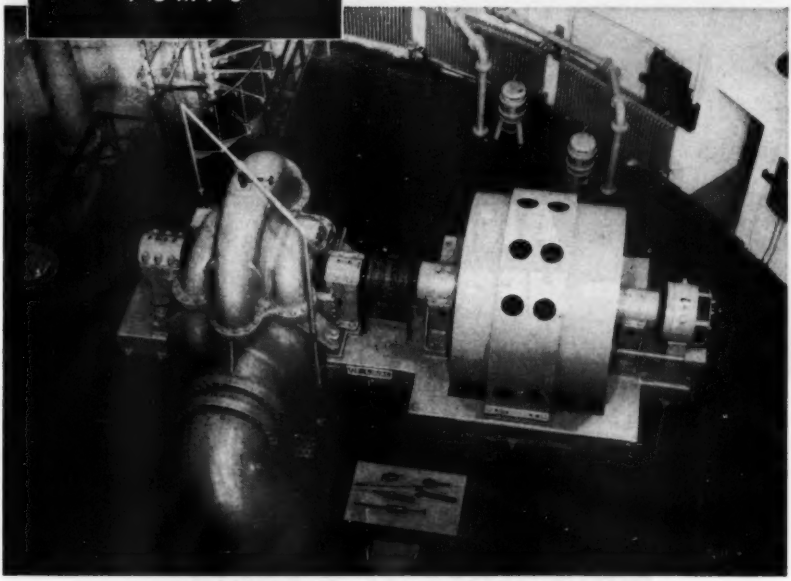
Here's why CHAPMAN Tilting Disc Check Valves *Keep Quiet* All Their Lives

This specially designed "airfoil" disc balances perfectly in open position . . . then drops easily to closed position (cushioned by the flow). No jarring or slamming, in usual pipe-layouts. Write for bulletin.

THE CHAPMAN VALVE MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

DE LAVAL
CENTRIFUGAL
PUMPS

help Louisville meet increased water demand



This 60 mgd, 200-foot head centrifugal pump is one of a group of De Laval units that help meet Louisville's expanding water needs. Today, this growing community is served by De Laval pumps with a total capacity of 314 million gallons per day.

Progressive Louisville, like 80% of America's largest cities, depends on De Laval to meet its ever-increasing pumping demands efficiently and economically for years to come. Such proven dependability is the result of over 50 years experience in pump building, during which time De Laval has perfected and introduced numerous "firsts" in pump design.

De Laval Centrifugal Pumps are available in capacities ranging from 100 thousand gallons per day to more than 100 million gallons per day . . . all built for long, dependable service.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

DL512A

. . . by protecting pipelines with Bitumastic® 70-B Enamel

● There are two ways to buy steel pipe for large-diameter water lines. One method is expensive—the other economical. You can buy *over-sized* pipe to allow for future loss in flow capacity caused by tuberculation and incrustation . . . or you can buy *smaller* pipe solely on the basis of desired capacity and then prevent "shrinkage" by using Bitumastic 70-B Enamel.

Flow capacity *stays* high when a spun lining of Bitumastic 70-B Enamel protects interior surfaces against rust, corrosion, incrustation and tuberculation. Flow tests, conducted on steel pipelines, centrifugally lined with hot Bitumastic 70-B Enamel, have shown the value of Hazen-Williams coefficient "C" = 145 to 170—the average being 155.

On wall thickness, too, you can save on steel by using Bitumastic 70-B Enamel. Applied to a thickness of approximately $\frac{3}{32}$", this durable enamel protects the exterior of pipe against the corrosive action of the soil. There's no need to specify an excess of wall thickness to compensate for corrosion. Just specify enough wall thickness to give the pipe adequate structural strength and then use Bitumastic 70-B Enamel to prevent corrosion.

Use strong, durable steel pipe, lined and coated with Bitumastic 70-B Enamel. It's a good combination—an economical combination. Write for full information.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC.

Tar Products Division, Dept. 1005-T, Pittsburgh 19, Pennsylvania

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

Me—I could write a buyer's guide!

When it comes to equipment, you can't fool maintenance men. They know what stands the gaff—and what doesn't. They also know a lot of their work is due to faulty selection of equipment—mistakes in judgment of quality, mainly.

In buying valves, such mistakes usually happen when someone buys on price alone, or because "all valves look alike." In either case, today's penalty is excessive maintenance at the highest labor rates in history. And where valve trouble causes production loss, it, too, was never costlier.

Standardizing on Crane valves eliminates a lot of mistakes, and it's the thriftiest habit in piping equipment buying. Better Crane quality and bigger selection assure it.

Crane Co., *General Offices:* 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*

CRANE

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

NOW for the first time . . .

a complete

well cleaning preparation

WELTONE

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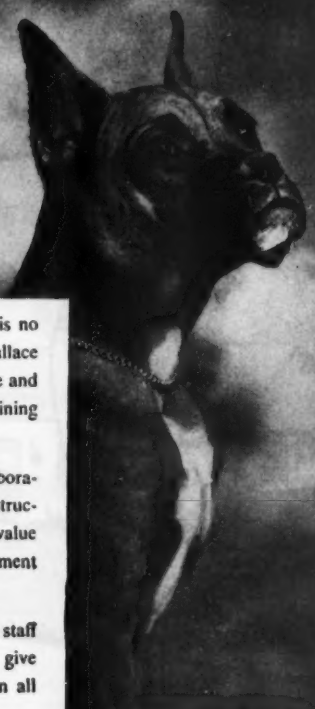

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 46 • OCTOBER 1954 • NO. 10

Control of Cavitation in Pressure-reducing Installations

By W. A. Kunigk

A paper presented on May 27, 1954, at the Annual Conference, Seattle, Wash., by W. A. Kunigk, Supt. & Chief Engr., Water Div., Dept. of Public Utilities, Tacoma, Wash.

PRESSURE reduction equipment in many water works is plagued by cavitation erosion. This paper describes the author's experience with two pressure-reducing installations in the Tacoma, Wash., distribution system and presents a practical approach to the elimination or mitigation of this difficulty.

Tacoma's Green River gravity supply is delivered to the distribution system in the city from McMillin Reservoir through two pipelines—13.1 and 15.3 miles long, respectively—with a combined capacity of 92 mgd. These lines operate under a static head from McMillin Reservoir (el 588) and can release water into the high- and low-service portions of the distribution system through pressure-reducing valves. The 30-mgd normal demand in the business section and industrial area of the city can be met from South Tacoma wells or by releasing water from one or both of the gravity lines into the pipeline from the wells to the low-service reservoir.

The pressure reduction from the two gravity lines to the reservoir is 140 psi. The operating conditions at the two pressure-reducing valves—a 16 × 12-in. Larner-Johnson valve on one line and a 10-in. cone valve on the other—are practically identical. Figure 1 shows the erosive action resulting from cavitation inside the cone valve after about 4 years of service. Similar erosive effects were observed on the inside of the Larner-Johnson valve. It was decided to ascertain what negative pressures existed in the venturi section below the cone valve. For this purpose, 24 ½-in. holes were tapped into this section to permit piezometric connections. All indications were that a perfect vacuum existed for several feet downstream from the valve. Air was admitted into this part of the pipe through an encasement in an attempt to remedy the trouble, but no beneficial

results were obtained. It soon became evident that ultimate failure would result if the two valves continued to be operated for any great length of time.

The author reached the conclusion that erosive cavitation could be eliminated or lessened only if all parts of the inner mechanism of the reducing valve were kept under positive pressure in direct contact with the stream. With this in mind, an experimental model was set up, using a 40-ft section of

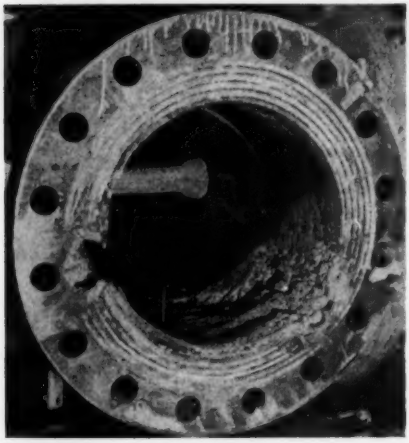

Fig. 1. Cavitation Erosion

The photograph shows the effects of cavitation erosion in a 10-in. cone valve after approximately 4 years of service.

16-in. diameter steel pipe with two 2-in. nozzles welded tangentially into the wall of the pipe. Water was supplied to these nozzles through two 2½-in. hose sections connected to a nearby hydrant operating under 175 psi. Piezometer pressure readings on the 16-in. line downstream from the nozzle connections showed that practically all the energy could be dissipated in a comparatively short section of pipe, with very little turbulence and almost no vibration. Consequently, it appeared that a solution to the problem could be worked out along these lines.

Because nearly 2,800 hp of energy would have to be dissipated in these two pressure-reducing valves when discharging 50 mgd (the estimated maximum), it was thought advisable to make precise observations on a small-scale test model of the proposed installation under laboratory conditions before trying to design a reducing valve

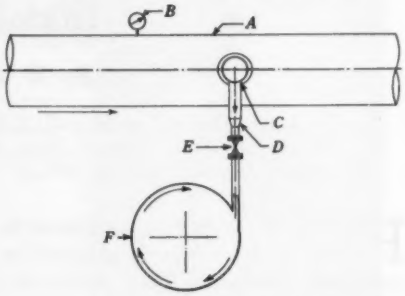

Fig. 2. Proposed Pressure-reducing Installation

Key: A—*48-in. gravity pipeline;* B—*145-psi pressure;* C—*16-in. supply header;* D—*8 × 4-in. reducer;* E—*4-in. round-port, full-area, semisteel, lubricated plug valve;* F—*36-in. discharge header.*

to meet the requirements. A model was built and a series of tests over a wide range of pressure and flow conditions was conducted at the hydraulics laboratory of the University of Washington by Harold K. Moritz, Prof. of Hydraulics, and Harry H. Chenoweth, Asst. Prof. of Civ. Eng.

Proposed Installation

It was proposed that each pressure-reducing mechanism should consist es-

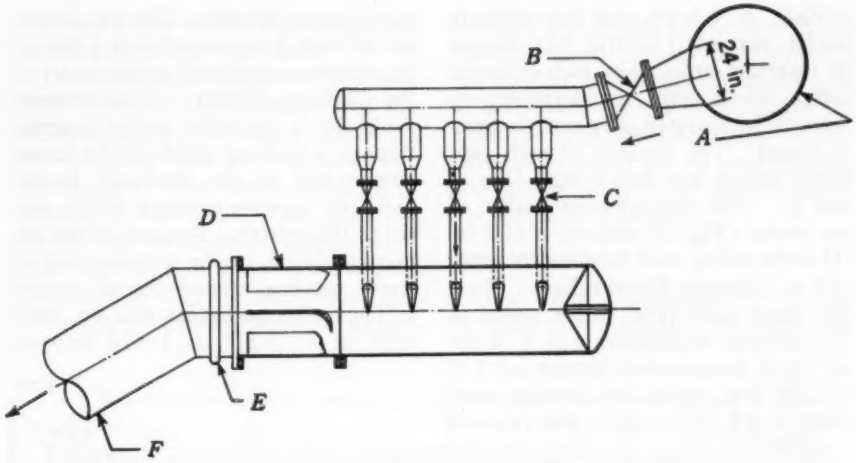

Fig. 3. Manifold Assembly

Key: A—*48-in. gravity pipeline;* B—*16-in. gate valve;* C—*4-in. plug valves;* D—*flanged-end straightening-vane section;* E—*mechanical coupling;* F—*discharge to pipeline from wells.*

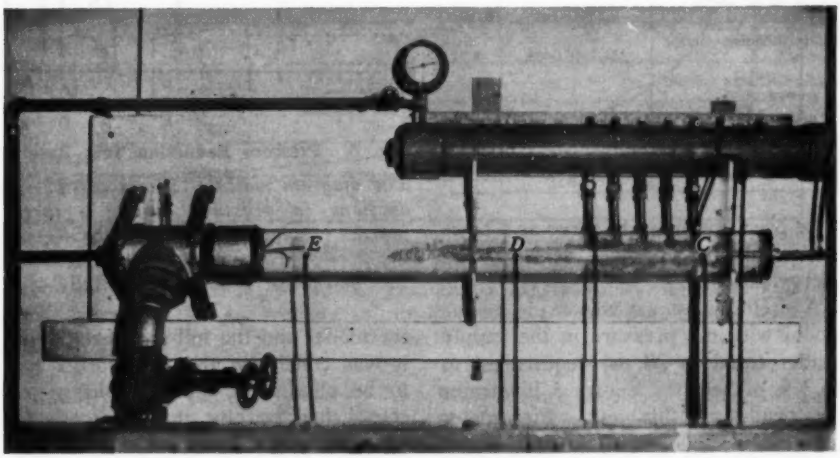

Fig. 4. Test Model

The high-pressure header, made of 4-in. diameter steel pipe, is connected to the 4-in. lucite low-pressure header beneath by five ½-in. Monel tubes, in each of which a metal disk can be inserted instead of a valve. Thus, the model may be operated with any number of tubes open or closed.

sentially of a high- and low-pressure header, connected by five 4-in. diameter manifold outlet pipes, each equipped with a full-diameter, round-orifice plug valve to be operated only entirely open or closed. The capacity of each pipe would be not less than 5 mgd (Fig. 2 and 3). The low-pressure header of the model (Fig. 4) was made of 4-in. ID lucite tubing, and the manifold pipes of $\frac{1}{2}$-in. diameter Monel tubing. Thus, the linear scale ratio of the model to the full-size installation was 1:9 for the 36-in. low-pressure header and 1:8 for the 4-in. pipes, the average ratio being 1:8.5. This figure was assumed to be precise enough to serve as a basis for calculating pressure, velocity, and energy ratios.

TABLE 1

Flow Calculations for Full-Scale Installation

Item	Calculation	Result
Assumed average pressure —*psi*		120
Velocity—*fps*	$\sqrt{64.4 \times 120 \times 2.31}$	133.5
Area of 3½-in. nozzle —*sq ft*	$\pi(1\frac{3}{4})^2 \div 144$	0.0668
Nozzle discharge volume —*cfs*	133.5 × 0.0668	8.92
Nozzle discharge volume —*mgd*		
1 nozzle	8.92 × 0.65	5.77
5 nozzles (1 unit)	5.77 × 5	28.85
10 nozzles (2 units)	5.77 × 10	57.7

A preliminary test was made on the model with the pressure in the supply header equal to 20 psi (equivalent to 46.2 ft of head). Figure 5 illustrates the results of this test. Piezometer tubes connected to water manometers indicated the head at *H* to be 9.7 ft, at *F* 8.3 ft, at *C* 7.5 ft, and at *G* 6.4 ft. Further downstream in the discharge header, a conversion from spiral flow to flow parallel to the axis of the pipe was very noticeable. There was also a rapid drop in pressure in the downstream direction. During a number of tests it was noted that a conical air vortex accumulated at the center of the discharge header. Measurements made by a movable probe inserted through a packing gland on the downstream end of the discharge header indicated negative pressure in the center of this vortex. Because of the uneven thickness of the annular ring of water rotating around the air vortex in the discharge header and the force ratio of $1:(8.5)^3$ or 1:614 between the model and the full-size installation, it was concluded that the vortex had to be eliminated. This could be accomplished by one of three methods: [1] attaching an air ejector to the upstream end of the low-pressure header; [2] producing back pressure on the downstream end of the low-pressure header; or [3] introducing straightening vanes in the header immediately below the last nozzle connection. The last solution was considered the most

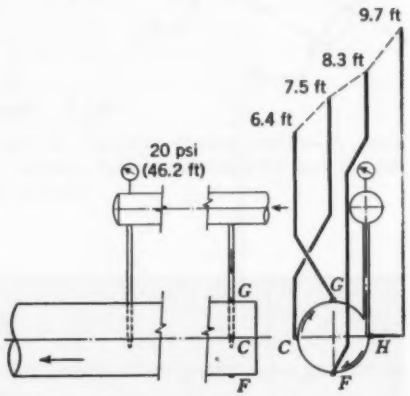

Fig. 5. Pressure Reduction Test Results

The diagram indicates the successive reductions in pressure during a three-fourths revolution (Points H-F-C-G) of the flow of water, which has entered the discharge header tangentially.

practical in view of the mechanical construction problems involved.

The insertion of copper straightening vanes caused the disappearance of the entire vortex, which was broken up into minute air bubbles that passed out downstream. The vanes extended a distance of one-fourth of the pipe diameter into the stream. The remarkable effectiveness of the vanes is clearly illustrated in Fig. 6, which compares the results of two tests on the model, with and without the use of vanes. In the latter test, the head at the downstream end of the vanes was reduced to about 1 ft.

From the data obtained in the model experiments, flow calculations (Table 1) were made for the full-scale installation. It is planned to install two units, as shown in Fig. 3, with a combined capacity of 57.7 mgd at an average pressure of 120 psi in the two transmission mains. Under this pressure, the amount of energy dissipated will be about 280 hp for each nozzle, or 1,400 hp for a five-nozzle unit. (This estimate is based on an energy ratio of $1:(8.5)^{\frac{1}{2}}$ or 1:1,798 for the model and full-scale installation.)

Conclusion

Many other arrangements of the manifold tubing between the high- and low-pressure headers, using different sizes and spacing, might give equal or even better results in the elimination of cavitation erosion and dissipation of energy than were obtained with the test model. The experimental observations were very encouraging, however, and appeared to furnish the information needed for working out the final design of the actual installation.

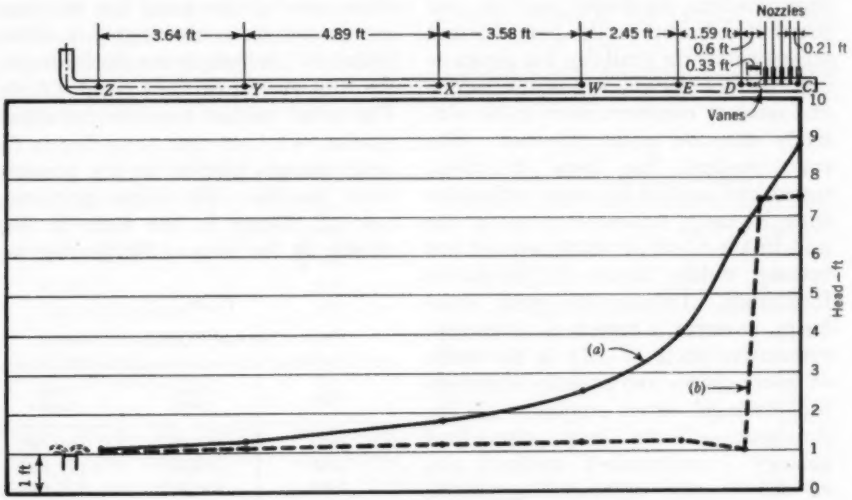

Fig. 6. Effectiveness of Straightening Vanes

Key: (a) 5-nozzle assembly, 14.0-psi pressure in supply header, no vanes; (b) 5-nozzle assembly, 14.5-psi pressure in supply header, copper straightening vanes in discharge header.

Forecasting City Population by the Ratio Method

By Robert C. Schmitt

A contribution to the Journal by Robert C. Schmitt, Cons. Sociologist, Honolulu Redevelopment Agency, Honolulu, T.H.

THE "ratio method" has won wide acceptance among city planners, demographers, marketing analysts, and social statisticians as the best shortcut means currently available for forecasting city population, yet water supply and sanitary engineers seem to be relatively unaware of its existence. The ratio method has been described, tested, and applied by many authorities since its early, rudimentary use in the mid-1920's (*1–6*), so that its value has become widely known to population forecasters. Despite this great popularity, however, a review of seven representative texts (*7–13*) in the fields of water supply and sanitary engineering disclosed seven accounts—all enthusiastic—of the long discredited analogy (comparative) method; six, of the equally outmoded geometric method; five, of arithmetic projection; two, of logistic extrapolation; four, of miscellaneous methods; and *none*, of the ratio method.

The application of the ratio method requires three fundamental operations: [1] computation of the local-to-national population ratio in 1950, 1940, and perhaps several earlier census years; [2] extrapolation of the trend indicated by these ratios to some future date; and [3] application of the projected ratio to an existing forecast of national population for the year in question. There are many ways to project the local-to-national ratio, ranging from simple arithmetic extrapolation of the trend for the most recent decade to the highly involved "shortcut" technique recommended by the US Bureau of the Census (*3, 4*). The latter method requires the classification of a local area according to the ratio changes plotted for the previous three decades. The initial postcensal rate of change in the ratio is then chosen on the basis of the average annual rate during the most recent 10-, 20-, or 30-year period, depending on the previously determined classification. This rate is graduated to zero over a period of 25 or 50 years, as the judgment of the forecaster indicates.

TABLE 1

Census Bureau Population Forecast

Year	Low *1,000's*	High *1,000's*
1955	164,403	164,782
1960	173,847	177,426
1965	180,927	189,916
1970	189,110	204,222
1975	198,632	220,982

Other techniques of projecting ratios include the fitting and extrapolation of a logistic curve, the use of a "least squares" arithmetic projection based on data for three or more census years, and simple arithmetic or geometric

extrapolation of the trend revealed by the two most recent censuses. These methods appear with varying frequency in recent literature (*2, 6*).

There is little reason to believe, however, that the method chosen for projecting ratios has much bearing on forecasting accuracy. As a test, the present author made 1950 "forecasts" using 1940 data for twenty large cities and then compared the "forecasts" to ratios computed from actual 1950 census data. Ratio projections were made by each of three methods: arithmetic and geometric extrapolation of the 1930–40 trend and the technique proposed by the US Bureau of the Census. For each of the three techniques tested, the average forecasting error (signs disregarded) was found to be 5.7 per cent.

TABLE 2

Accuracy of Forecast Methods

Forecast Method	Avg Error *per cent*
Ratio	5.7
Cohort survival	5.9
Labor force analysis	7.9
Component	10.3
All others reported	9.4

No matter which means of projecting the population ratios is adopted, the final step requires the careful selection of a good forecast of national population for the desired year. Such forecasts are issued from time to time by the Census Bureau, the most recent being a series published in August 1953 (*14*). Alternative estimates were published for quinquennial periods from 1955 to 1975, based on various assumptions regarding fertility and mortality. The high and low forecasts of United States population given in this source are cited in Table 1.

It should be noted that these forecasts include armed forces overseas. To render the estimates comparable with decennial census data, a deduction of perhaps 2,000,000 persons should be made to allow for this overseas population.

Comparative Accuracy

Siegel (*5*), in a review of 99 studies made prior to 1950, found that the ratio method had proved the most successful of all techniques used. The average errors of the various methods are shown in Table 2.

Schmitt and Crosetti (*6*) reported similar findings in a test of five commonly used forecasting techniques. The test involved making 1940 and 1950 "forecasts" for twenty American cities (the same cities used in the test previously described), based on 1930 data, and then comparing the "forecasts" with the actual enumerated population for 1940 and 1950. Both the logistic curve (as applied to actual figures, not ratios) and the ratio method showed considerable superiority over other techniques, as indicated by the average percentage errors (Table 3). The poor showing of both the analogy method and geometric projection—the two methods that engi-

TABLE 3

Forecast Accuracy (20 Cities)

Forecast Method	Avg Error—*per cent*	
	10-year Forecasts	20-year Forecasts
Analogy (comparative)	34.9	61.8
Geometric	33.0	61.0
Arithmetic	14.2	18.8
Ratio	9.3	15.6
Logistic	8.8	10.6

neering textbooks continue to mention most frequently and most favorably—should be especially noted.

The importance of accurate population forecasts for planning water supply and sanitary facilities has long been recognized. The usefulness of the ratio method for making such projections should now achieve similar recognition.

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Discussion

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It is true that the ratio method, as outlined by the author, has won wide acceptance among population forecasters. Water supply engineers are more familiar with it than textbooks may indicate. In fact, one variation or another of the ratio method was relied on by practically all the engineers (probably a dozen or more) who commented on or criticized the Metropolitan Water Dist. Colorado River Aqueduct plans 20–25 years ago. These plans were, of course, supported by and based on population and water demand forecasts for the Southern California coastal region.

It has been the writer's experience that even the official United States population forecasts, although generally accepted by experts when issued, are not as infallible as a forecaster might wish. To illustrate this point, the averages of the official high and low forecasts, as quoted by the author (Table 1), are compared in Table 4 with the averages of similar high and

low forecasts of the 1930–40 decade, which were then equally accepted by all informed persons. A frequently quoted forecast made in 1927 is also listed. As late as June 1930 the 1927 forecast was called "quite optimistic" by its author, although it now seems rather the reverse.

The error of the depression-affected 1937 forecast is 13.1 per cent for 1954, and its variation from the official 1953 forecast for 1975–80 is 30–35 per cent. Such errors in the 1930–40 forecasts necessarily influenced all ratio method projections based on them. It is not improbable that the currently official and accepted United States forecasts may, by or before 1970, be found to have been affected, at least to some extent, by recent boom conditions, so that present ratio method projections may prove to be optimistically high. In any event, this possibility cannot entirely be ignored.

TABLE 4

Comparison of Forecasts

Year	Census Data & Current Estimates	Avg of High and Low Figures		
		1953 Forecast*	1937 Forecast†	1927 Forecast‡
	US Population—*1,000,000's*			
1920	105.7			
1930	122.8			
1940	131.7		131.7	138.3
1945	141.0§		135.5	145§
1950	150.7		139.0	151.6
1954	161.8		140.6	156§
1955	164.6§	164.6	141	157§
1960		175.6	143	162.7
1965		185.4	144	167§
1970		196.7	145	171.5
1975		209.8	144	175.1
1980			143	

* US Census Bureau (see Table 1).
† Made by Thompson and Whelpton for National Resources Committee (quoted in Reference 1).
‡ Made by Whelpton for Scripps Foundation (quoted in Reference 2).
§ Interpolated.

Even among water supply engineers, few are aware of the wide variation in recent United States forecasts, all official and accepted by the experts, all perfectly logical and mathematically derived. Likewise, the astonishing inaccuracy of expert forecasters for the early 1940's is seldom recalled.

With regard to the second major component of the author's forecast method, the local-to-national population ratio, similar difficulties, in even greater degree, have often been encountered. Reverting again to Colorado River Aqueduct experience, the same group of 1930–34 forecasters proved that this ratio was (and is) indeterminate, at least in a rapidly growing region such as the Southern California coastal plain. For this area, the ratio has increased continuously, but not uniformly; in 1890 it was 0.28 per cent; in 1930, 2.2; in 1950, 3.5; and in 1954, about 3.8. The rate of change in the ratio was only one-third as large for the 1930–40 depression period as for the preceding decade, but for 1940–50 it was again almost as high as the earlier maximum. Just how soon this ratio curve will flatten out, as it obviously must eventually, cannot be extrapolated satisfactorily—for this region, at least—even with the help of suggested mathematical methods.

Too great reliance on the ratio method, used possibly as rationalization or window dressing for preconceived opinions, has led various admitted experts to commit serious blunders, a few examples of which will be cited. In 1934 Hay (*3*) applied the ratio method to Los Angeles population growth and concluded:

The growth of large cities conforms pretty closely, in the long run, to the growth of the supporting population. In spite of its climate, Los Angeles is no exception to this generalization. . . . The city fathers permitted themselves to be deceived into thinking that Los Angeles would continue to grow much more rapidly than the whole country. . . . Many other communities in Southern California committed the same offense against reason, and out of their aggregate estimates Boulder Dam was conceived and is destined to become a monument to the fallacy that abnormal population movements continue indefinitely.

Another authoritative statement (*4*), published about the same time and based, at least in part, on the presumed indications of the ratio method, reads as follows:

The greatest single movement in the entire history of the country, one of the greatest in the world, has been the migration to California in the last decade [1920–30]. . . . Since this [population] movement is abnormal in most respects, it is inconceivable that it will continue.

A Los Angeles expert, W. C. Yeatman, reporting in August 1932 for a taxpayers' group, was similarly misled by a then current national forecast:

All conclusions based upon [Metropolitan Water Dist.] studies of the future population of Los Angeles and the Metropolitan Water District are undoubtedly faulty, for the reasons stated [including] . . .: (a) There is a distinct tendency for a city to grow in proportion to the country as a whole, after it has passed its initial rapid period of growth. (b) This recent land speculation, with its consequent migration of exfarmers to the Pacific Coast, is something never likely to repeat, even in the lifetime of our grandchildren. . . . (c) Even another war would not produce another migration to California such as we had prior to 1925 . . . a most abnormal growth, due to conditions which will never repeat. . . . (d) The rate of growth of the country as a whole must always be a dominant factor in the growth of Los Angeles.—Therefore:

A broad consideration of every factor demonstrates clearly that the Metropolitan Water District lacks sound economic basis of justification.

The Metropolitan Water Dist. now has a water service area and an assessed valuation about four times as great as in 1932 and is engaged in a $60,000,000 expansion program in an effort to keep ahead of its growing water demands.

In spite of these examples (a bit outdated because such errors require a great deal of time to develop), the ratio method of forecasting population is an important tool for engineers reluctantly drafted as prophets. The method is especially useful as a check on other common forecasting techniques. It works best when qualified by judgment and discretion and accompanied by considerable luck. Neither this nor any other method should be relied on dogmatically, particularly in unusual migration areas like the Pacific Coast States.

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Local Water Systems in Reclamation Areas

By James C. Howland

A paper presented on May 26, 1954, at the Annual Conference, Seattle, Wash., by James C. Howland, Partner, Cornell, Howland, Hayes & Merryfield, Corvallis, Ore.

FURNISHING water for the irrigation of crops is the principal concern in most reclamation projects. The irrigation system, however, is only one of the many construction features that may be involved. When an arid region of hundreds of square miles, essentially uninhabited and remote from any but crossroads communities, is suddenly irrigated and becomes the home of a farm population of several thousand, all sorts of supplementary facilities are required—drainage systems, roads, schools, cities, and rural and urban water utilities. These features, in the aggregate, may represent a capital outlay exceeding the cost of the irrigation system itself.

It is not the intention of this paper to criticize the activities of the US Bureau of Reclamation in the domestic water supply field. It is, however, desired to point out that domestic supplies for farms and the related municipal water systems are of major importance in a reclamation area and that federal procedures covering appropriations for such purposes make the most efficient use of these funds difficult. It also appears that the philosophy of some federal design and construction agencies is foreign to the usual thinking on such problems.

Deschutes North Unit Project

In examining the domestic water supply problem in reclamation areas, the system serving the North Unit of the US Bureau of Reclamation's Deschutes project in central Oregon will be principally considered. The North Unit irrigates 50,000 acres (80 sq miles) located on an arid lava plateau along the east banks of the Deschutes and Crooked rivers. The area lies just east of the Cascade Range, approximately 70 miles south of the Columbia River and 40 miles north of the city of Bend, Ore. It contains the towns of Madras (population 1,258), Metolius (population 157), and Culver (population 310). The elevation of the plateau ranges from 2,000 to 3,000 ft above sea level. In this region, the Deschutes and Crooked rivers flow through sheer rock canyons 800–1,000 ft deep. The Cascade Range, which parallels the west bank of the Deschutes River, has a general summit elevation of 5,000–6,000 ft above sea level and contains a series of peaks 9,000–11,200 ft high. In the irrigated area, the average annual precipitation is 8.6 in., with only 1.1 in. falling during June, July, and August. July temperatures average 66°F and January temperatures 31°F. Extreme temperatures of 112° and −45°F have been recorded. Most of the area is provided with a domestic supply by a water district that, although 22 miles long and 7 miles wide, serves only 700 customers, including residents of Culver and Metolius.

The region was first settled in the 1870's and 1880's and was used chiefly for grazing, with emphasis on sheep production. Grazing was largely replaced by dry-land wheat farming during a wet cycle in the early 1900's. Later dry cycles forced the abandoning of much of the wheat farming, with a resulting drop in population. The rugged Deschutes Canyon was the scene of a railroad war between the famous tycoons, James J. Hill and Edward H. Harriman, in 1909–10. Rival railroads were built at the same time up the narrow canyon in a race for the city of Bend. Much of the way, there was no satisfactory location for one railroad, let alone two, and some bitter fights took place.

The development of domestic well water supplies has only been feasible in a portion of the area that is now irrigated. In the sections containing most of the irrigable land, the results of well drilling have been extremely disappointing. Wells in which water has been produced range in depth from 240 to 1,690 ft, the majority being 400–600 ft deep. In some, production has been as low as, to quote from reports, "1½ barrels per day." A dug rock well, 200 ft deep, produced no water at all, and Madras has drilled two wells more than 500 ft deep which turned out to be "dusters."

On the plateaus where the farms are located, there are only intermittent streams and a few seeps, while, in the bottom of the canyons, large volumes of water flow in the Deschutes and Crooked rivers, as well as in fabulous springs. The largest of these is Opal Springs, located near the south end of the North Unit irrigated area. The combined flow from the series of outlets at Opal Springs exceeds 300 cfs, a sizable river in itself. The flow from the springs is essentially uniform the year round; the clear, sparkling water is free from contamination and has a calcium carbonate hardness of 53 ppm and a maximum summer temperature of 54°F. Opal Springs and others along the canyon are a source of excellent domestic water, but the cost of getting it out of the 900-ft canyon and distributing it to widely separated farms is beyond the resources of almost any single farmer and can be met only through community action.

An enterprising engineer and inventor in the area obtained rights at Opal Springs and developed rather unconventional water-powered pumping equipment for the 900-ft head. Water districts were formed, and, in the period 1917–27, a system serving most of the irrigated area now supplied by the Deschutes Valley Water Dist. was built. The design standards were not high, as the financial resources were limited. Static system pressures ranged from 10 to 175 psi, 1-in. and 2-in. "mains" served extensive areas, and the reservoirs were small. This system was, however, a great improvement over hauling water for long distances, catching rain water, and living for extended periods with only the minimum water required for drinking and cooking.

With the great influx of people into the area after World War II, owing to the completion of the Reclamation Bureau irrigation system, the water systems were hard pressed to meet the demands. More than $300,000 was spent on improving rural facilities and another $100,000 was expended on the storage and distribution installations at Madras, where the problem was particularly serious. Its population had grown from 400 to 1,200 in a few years. On the farms, it was possible to irrigate the trees, gardens, and lawns with ditch water during the summer.

but this was not a suitable source of supply for the town. The use of filtered ditch water was not a year-round solution, because the ditches only carry water during the irrigation season. Any new water supply development for the city meant a cost beyond its economic capabilities until it grew sufficiently, and it could not grow without an adequate supply. In complaining of the dusty and treeless city, one young housewife bitterly decried the situation and flatly stated that she was not going to "suffer as Grandmother did on an irrigation project in Idaho."

Plans for Domestic Supplies

The expenditures on the city and district systems helped, but they were not enough and full return for the money spent was not received, owing in part, at least, to inadequate engineering and poor operation. In an effort to improve the situation, groups in the area urged the federal government, through the Bureau of Reclamation, to build and finance a domestic water system. In a report on the subject published in 1950, the Boise, Idaho, regional office of the Bureau of Reclamation stated that the bureau has no legal authority to construct water systems, except where they are naturally incidental to the irrigation facilities of a federal reclamation project. In 1951 a second report recommended that the water system be constructed, operated, and maintained by the Bureau of Reclamation in accordance with the Federal Reclamation Law of 1902, as amended, but that no expenditure for construction be made until a satisfactory organization was set up to repay it. The report proposed to utilize Opal Springs as the source of supply and to construct completely new pumping, storage, and distribution facilities at an estimated cost of $3,500,000. It was recommended that the cost be repaid over a 50-year period and that the expenditure for the portion of the system required to serve urban users carry an interest charge of 2 per cent. The remaining cost, approximately $3,000,000, chargeable to the rural system, was to be repaid without interest.

While these reports were being prepared, improved management and operation succeeded in bettering the service from the enlarged Deschutes Valley Water Dist. system, which serves approximately 80 per cent of the irrigated area. Unaccounted-for water was greatly reduced (an important item when water costs 10 cents per 1,000 gal delivered at the initial distribution reservoir); outages were largely eliminated; and the system showed an operating profit.

Also at this time, the Deschutes Valley Water Dist. and the city of Madras joined forces to engage engineers to study the supply problem for the area. They developed preliminary plans for a supply and distribution system, estimated to cost $1,700,000, which would use much of the existing supply, storage, and distribution facilities. The proposed system, however, would leave unserved approximately 20 per cent of the irrigated area, most of which depends on wells. The system is set up for construction by stages: the $700,000 supply facilities would be built in three steps, as the water requirements increase; and the $1,000,000 storage and distribution improvements, including two reservoirs and 48 pipelines, would be provided as the need arises and funds can be obtained. It was proposed that, in the initial years, approximately $35,000 annually available from current revenues be expended on the distribution system. It was felt that such a program, even if

inadequate when judged by many standards, would at least furnish all of the people with water all of the time.

Comparison of Plans

The plans of the Reclamation Bureau and the private engineering firm are remarkably similar in general concept. The difference in estimated cost stems principally from a basic difference in design philosophy and standards. The bureau's preliminary study is based on abandoning almost all of the existing supply, storage, and distribution facilities and constructing a new distribution system with mains along each of the section line roads. In the plan prepared for the city and the water district, existing facilities are used to the fullest extent, distribution improvements would be made on a cash basis, and distribution lines into new areas would be constructed only when there are customers to serve. A portion of the land is farmed by persons living in the cities or is leased by other farmers in the region; thus, there may be areas where a main down each section line road is not needed. The bureau's plan serves approximately 25 per cent more area than the other.

It is believed that the bureau's one-step plan is the result of congressional appropriation procedures. It may be suitable for an irrigation system when all the irrigable land is included in a project and the entire program is carried out at once, but the location of a domestic water supply depends upon where the prospective consumers live. With people the individualists they are, their residences may not be situated in accordance with a master planner's ideas on the subject.

It appears at this time that, chiefly because the service from the water district system has been improved, most people in the North Unit area do not want to be saddled with a $3,500,000 debt—even interest free—and would rather work the problem out through their local organization. The water district administration is relatively closely controlled by the people through the election of directors and attendance at district meetings.

It is conceivable that a local water district arrangement might not be feasible in some reclamation areas. Such a solution would not have been possible in the Deschutes Valley Water Dist. area without the previously existing system. The Oregon Water District Law limits the amount of bonds a district can issue to 10 per cent of the assessed valuation. This restriction would prevent the raising of sufficient funds by a bond issue to build an entirely new water system for the area.

In parts of the large Grand Coulee irrigation development in the Columbia Basin, domestic water supply is being provided by wells developed by groups of farmers. The wells are deep and, in general, beyond the financial limitations of individual farmers. Consequently, several farmers get together to drill a well and pipe the water. The federal agricultural agencies help with the engineering and lend the capital required.

It is felt that, in the study of any reclamation project, the matter of domestic water supply must be carefully considered and its cost included in the economic analysis. In the Deschutes North Unit project, the cost of the irrigation system per acre is not particularly low, but the expense of the Bureau of Reclamation's domestic water system is estimated to be more than a quarter of the irrigation system cost.

Survey of Water Revenue Bond Financing

Joint Discussion

A joint discussion of a paper presented on May 26, 1954, at the Annual Conference, Seattle, Wash., by D. L. Erickson, City Engr. & Director, Dept. of Parks, Public Property & Improvements, Lincoln, Neb. The Erickson paper was published prior to the Annual Conference, in the April 1954 Journal (Vol. 46, p. 325).

Editor's Introduction

The results of a recent survey of water revenue bond financing in the United States (questionnaire returns were received from 69 cities, representing every state except Nevada) led D. L. Erickson to draw the following conclusions:

1. The financing of water works improvements by water revenue bonds has become a widely accepted practice, as evidenced by the fact that cities in at least 38 states are now permitted to issue such bonds.
2. Approximately two-thirds of the states permitting the issuance of water revenue bonds do not require a vote of the electors.
3. More than half of the cities with authority to issue such bonds can do so for terms of 40 years or more.
4. More than two-fifths of the cities with authority reported no legal limitations on the total amount of such bonds.
5. More than three-fourths of the cities with authority do not give a mortgage upon the physical property of the water works system as security for water revenue bonds.
6. More than three-fifths of the cities with authority are not permitted to use the city taxing power as security.
7. The interest rate on water revenue bonds has varied from 1.67 per cent on a 20-year bond issued in 1951 to 4.0 per cent on a bond with a similar term issued in 1934.
8. In the experience of the cities reporting, the interest rate on water revenue bonds is 0–1.5 per cent higher than on similar-term general-obligation bonds.
9. The highest debt service ratio requirement reported was 1.5 per cent.

G. W. Francis

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Revenue bonds were used as early as the twelfth century by the city of Venice and have been commonly employed in England since the eighteenth century. In the United States, their first appearance was in 1895, when Spokane, Wash., financed a rehabilitation of its water works system. It took the depression of the early 1930's, however, to popularize this type of financing. The Municipal Finance Officers Assn., in reply to a recent query by the writer, listed 38 states and the territories of Alaska, Guam, Hawaii, and Puerto Rico as granting legal authority for issuing revenue bonds, although some states have certain restraints on the types of revenue-producing facilities involved. It appears that revenue bonds will increase in importance as a method of financing public works.

During the first 3 months of 1954 offerings of tax-exempt bonds throughout the nation totaled $1,300,000,000, which set an all-time record for a quarter. Undoubtedly revenue bond financing played an important role in this record offering.

In presenting his opinions regarding various aspects of this subject, the writer is relying on his experience in working with others in the field. Because revenue bond legislation varies from state to state, the writer's comments will be general in nature, reflecting what he considers the best practice in this type of financing.

Bond Elections

The electorate should have some control over public officials in the issuance of such bonds. A reasonable and effective method—and one that will not unduly hinder officials in obtaining financing for self-liquidating projects —is to allow the right of referendum, based upon a petition signed by not less than 10 per cent of the registered electors and filed within 30 days subsequent to publication of the ordinance by the governing body. Approval of the ordinance should be by a simple majority of those qualified to vote at a general or special election. As revenue bonds are not a lien upon taxable property, the voting should not be restricted to taxpayers.

To meet the demands of expanding population and rising standards of living requires financing beyond the scope of general-obligation bonds. Because the average municipality is limited in the types of projects suitable for revenue financing, because a water works system should be self-supporting, and because, in general, water revenue bonds are near or at the top in salability, it follows that they should be given serious consideration in any water utility financing program.

Legislative Limitations

Revenue bond legislation should allow the full pledging of all receipts from the operation of any new or existing water system to meet utility operating expenses, including debt service.

There is little need for specifying a maximum term of years in a revenue bond act, as the market conditions will reasonably govern this matter. If a limit is to be set, however, it should be 35–40 years. In general, a project requiring more than 40 years to liquidate, especially in the water works field, is not a sound venture. On the other hand, good water utility projects costing less than $1,000,000 will very often require a bond life of 30–35 years.

As the market will accept only those revenue bonds which can be supported by the earnings of the project, based upon reasonable service charges, it seems superfluous for lawmakers to attempt to guess the future financing needs of communities by placing a limit on the amount of such bonds. This procedure may prove a hindrance in certain situations.

Interest Rate

The difference in the interest rates of revenue and general-obligation bonds, a subject of considerable debate, varies with the market and the size of the issue. Currently, on projects costing less than $1,000,000, it is perhaps 1–1.5 per cent in favor of general-obligation bonds; on more costly projects, the difference is smaller. To retain the utilitarian aspects of a water works system and reserve the taxing capacity of a community, it is usually worth paying the higher interest, but

the possibilities of combining several types of financing should be kept in mind.

Debt Service Ratio

The "debt service ratio" is derived by subtracting the annual operation and maintenance cost of the utility from the total receipts and dividing the net by the total debt service (principal plus interest) for the same year. The optimum ratio at the present time is 1.5. It is advisable not to let this ratio fall below 1.4, and even that minimum should be permitted, if at all, only in the later years of the issue. A few years ago many issues were sold at ratios of 1.30–1.35. As market conditions and the circumstances of the particular project govern this matter entirely, the debt ratio is not a subject for legislative control.

Sale of Bonds

Revenue bonds should be offered for sale by competitive bidding in order to protect the public and to maintain a measure of dignity in this field of finance. The popularity of such issues will increase when they rise above the "dicker" stage in all states. The standby bid and the aid of a financial consultant are often useful, especially when outstanding bonds must be retired. Such assistance is not always necessary, however, particularly in municipalities that have experienced financial directors or consulting engineers familiar with finance.

Tax Exemption

There has recently been some talk, at the federal level, of taxing revenue and other types of municipal bonds. Such action would be a disastrous blow to water works operation.

Conclusion

It would seem that one of the greatest needs in the field of revenue bond financing is uniformity in legislation throughout the various states, based upon a model act, if one can be found or devised.

L. W. Grayson

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Many instances might be cited to support the statement that the voters are more inclined to approve measures for incurring public indebtedness if the repayment obligation is limited to a specific source of revenue. The electorate is often skeptical of politicians' assurances that a debt will not result in an increase in ad valorem taxes.

In the matter of financing water works through the issuance of revenue bonds, California cities have for many years been troubled by a constitutional provision that prohibits the incurring of debt without a favorable two-thirds majority vote. In an outstanding historical case (*1*) on this subject, decided in 1932, the court seemed to adopt what is called the "limited special fund theory," which requires that revenue obligations created by a city water works improvement be paid only from the proceeds obtained from the additions. In contrast, the "broad special fund theory," which is the doctrine in most of the states, permits the repayment of revenue obligations for additions and improvements from all the receipts of the utility.

In 1929, however, the court had decided (*2*) that the Los Angeles Dept. of Water and Power could issue revenue bonds under the broad special fund theory. Thus, the 1932 decision resulted in reviving the question.

Finally, in 1933, the proposed improvement bonds under attack were held valid by the court, which ruled that the constitutional prohibition did not apply (*3*).

A peculiar aspect of the 1933 decision, which was reaffirmed by the state supreme court in another case later that year, was the ruling that a separate board controlling a city-owned public utility department could issue revenue bonds as an obligation on all the revenues of the utility. The finding of the court did not, however, nullify the 1932 decision upholding the constitutional provision.

In order to obtain authority to issue revenue bonds for the improvement of water and electric facilities, Glendale, Calif., in 1949, employed bond counsel to draft the necessary charter amendment. In a test suit, the district court of appeals, in 1951, upheld the validity of the amendment and the revenue bonds to be issued under it. As the state supreme court afterward refused to hear the case, there is still a degree of doubt regarding the status of the 1932 decision, the clarification of which is desired by many utility operators.

Since the 1951 decision in favor of Glendale, the neighboring city of Pasadena has prepared a similar charter amendment, whose validity, in the opinion of counsel, need not be tested in court. The authority to issue revenue bonds is stated succinctly, and, unlike the Los Angeles city charter, the limitations imposed are brief and include very little detail.

The purpose in citing the foregoing is to illustrate that it is almost as difficult to formulate a universally applicable statement of revenue bond authority as it would be to establish a detailed standard of similar applicability with regard to the preparation of a bond issue itself.

In the latter connection, perhaps the principal consideration is that revenue bonds are a commodity offered for sale in a very competitive, fast moving market. The prospective buyers are knowledgeable and act upon the advice of experts who carefully examine the product to be sold and overlook no detail, however small.

Experience seems to indicate rather strongly that the individual utility should strive to develop a sound basic bond issue pattern suited to its circumstances. Once the market's acceptance of such a pattern is established through favorable sales, the utility should hold to that pattern in future issues. On the other hand, if an issue fails to find favor in the market, the pattern should be subjected to examination and review in order to better the utility's position.

It is evident from the survey results reported by Erickson that water revenue bond issues are increasing in number, although the survey was too limited in scope to indicate the degree of acceptance of this form of financing. The observation on the difference in interest rate between revenue and general-obligation bonds (Conclusion No. 8) for similar terms should be considered in the light of the fact that extreme changes in interest rates have occurred in a short period of time, so that comparisons made even on bond issues no more than a year apart may not be valid.

References

1. 216 Calif. 220.
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Passage of Nuclear Detonation Debris Through Water Treatment Plants

By Carlos G. Bell Jr., Harold A. Thomas Jr., and Barnet L. Rosenthal

A contribution to the Journal by Carlos G. Bell Jr., Asst. Prof. of Civ. Eng., Technological Institute, Northwestern Univ., Evanston, Ill.; Harold A. Thomas Jr., Assoc. Prof. of San. Eng., Div. of Applied Science, Harvard Univ., Cambridge, Mass.; and Barnet L. Rosenthal, Chief of Lab., Lawrence Experiment Sta., State Dept. of Public Health, Lawrence, Mass.

FOLLOWING nuclear detonations, hot radioactive products may rise thousands of feet into the air and thereafter be subjected to the prevailing air mass movements. It is not unusual for air masses that pass over Nevada to be above New England 2 days later. As fission material decays very rapidly at first, the rate of transportation has an appreciable effect on the initial intensity of the radioactive fallout. This fission debris is deposited on the earth, a part of it often at great distances from the detonation. From November 1951 to June 1953, a period in which there were approximately 24 blasts, only about five were followed by a fallout in Massachusetts large enough to raise the radioactivity of surface waters significantly above natural levels.

Several widely separated laboratories (*1, 2*) have discovered relatively large amounts of fallout from nuclear detonations. Surprisingly large radioactive particles (22 μ in diameter) of Nevada origin have reached the Oak Ridge National Lab. in Tennessee (*3*). The authors' experience, as well as that of others (*4, 5*), indicates that rainstorms may contain rather high concentrations of fission product radioactivity. Furthermore, the authors have found that significant increases in activity in streams occurred only when precipitation took place in the presence of radioactive air masses. For example, the radioactivity accompanying a rain following the Apr. 25, 1953, Nevada detonation gave a large reading in the Troy, N.Y., area, but no appreciable increase was detected at that time in the surface waters of eastern Massachusetts or in Lake Ontario near Rochester, N.Y. No unusual readings were reported in the Rochester area on Apr. 7–8, 1953, but a rainstorm in eastern Massachusetts produced a very large fallout, which was quite probably from the Apr. 6 Nevada detonation.

Although there have been several pilot plant investigations of the removal of radioactivity from water, little has been reported on the passage of long-range fallout through water treatment plants (*6*). Data presented herewith show the radioactive-fallout removal efficiencies at three water filtration plants. It will be seen that these efficiencies are lower than those obtained in pilot plant studies (*7*) and far smaller than specu-

lative estimates reported in other investigations (*8, 9*). Operational data pertaining to the filter plants are presented in Table 1.

Measurement Techniques

All measurements, reported from three different laboratories, were made by similar techniques and instruments. In all instances, the water samples were evaporated and the solids carefully transferred to steel cup planchets of the same size. Data were collected at rapid sand filtration plants located in Cambridge and Lawrence, Mass., and in the Rochester, N.Y., area. The water samples from the Rochester area plant were each 4 liters in volume; those in Cambridge, 1 liter; and those taken at Lawrence, 100 ml. Radioactivity count rates (principally beta, with some gamma, radiation) of the evaporated residues were measured with lead-shielded Geiger-Muller tubes that had thin end windows consisting of approximately 2 mg of mica per square centimeter. Samples were taken simultaneously at all treatment stages and were nearly always counted in close succession. The differences in the total solids in the various stages at each plant were not enough to affect appreciably the relative values of the count rate readings, except for the Rochester area plant sludge and backwash samples.

TABLE 1

Filter Plant Data

Item	Cambridge, Mass.	Lawrence, Mass.	Rochester, N.Y., Area	
			Rapid Sand	Slow Sand
Quantity treated—*mgd*	17	8	34	4
Solids in influent—*ppm*	70*	76†	165†	165†
Solids in effluent—*ppm*	105*	84†		
Chemicals				
Alum—*ppm*	19	34	22	0
Lime—*ppm*	8.4	13	‡	0
Total chlorine—*ppm*	0.5	2.8	1.1	1.1
Detention period				
Flocculation—*min*	45	20	5	
Sedimentation—*hr*	2	5.4	1§	
Filter sand				
Depth—*in.*	27	30	25	24
Effective size—*mm*	0.50	0.46	0.42	0.20
Uniformity coefficient	1.5	1.9	1.5	1.5
Filtration rate—*gpm/sq ft*	2.3	2.24	2.0	0.18
Avg filter run—*hr*	36	59		8

* Dissolved solids. † Total solids. ‡ Soda ash added. § Solids-contact process basin.

All evaporated samples from the Cambridge plant were weighed on an analytical balance, and corrections were made for geometry, backscatter, and self-absorption. Factors for these corrections were obtained from calibration measurements made with five pure radioisotopes, having different energy levels, whose disintegration rates had been established by the National Bureau of Standards. The corrected val-

ues obtained were then converted to micromicrocuries per liter (1 μμc corresponds to a nuclear disintegration rate of 2.2 per minute). A decay correction was made, based on the "1.2 law," * assuming that all the radioactivity measured was created in the Nevada detonation of Apr. 6, 1953. These corrected values are given in Table 2 in micromicrocuries per liter, along with the uncorrected count rates. Ratios of the activity of the effluent of the various stages of the Cambridge plant to the activity of the raw influent are also given. The only important difference between the ratios for the counts and for the corrected values is seen in the tap samples taken soon after the large fallout. This difference was due chiefly to the decay correction, because the time interval between collection and measurement was shorter for the laboratory tap samples than for the plant samples.

TABLE 2

Radioactivity at Cambridge Plant

Assumed Detonation Date	Sampling Period	Sampling Point*	No. of Samples	Observed Radioactivity				Relative Activity	
				Avg		σ_s†		From cpm/l	From μμc/l
				cpm/l	μμc/l	cpm/l	μμc/l		
	2/9/53–	R	24	1.27		0.14		100	
	4/7/53	S	14	1.34		0.19		105	
		F	13	1.57		0.21		124	
		T	3	0.98		0.43		77	
4/6/53	4/8/53–	R	10	20.70	187.0	0.36	3.9	100	100
	4/21/53	S	9	13.08	117.5	0.30	3.0	63‡	63
		F	9	10.43	90.1	0.27	2.4	50‡	48
		T	2	6.75	30.0	0.62	2.1	33‡	16
4/6/53	4/22/53–	R	24	4.30	14.52	0.16	0.55	100	100
	5/18/53	S	25	3.07	10.39	0.14	0.51	71‡	72
		F	25	2.63	8.99	0.15	0.53	61‡	62
		T	18	3.36	11.08	0.17	0.56	78‡	70
4/6/53	5/19/53–	R	31	2.85	9.19	0.13	0.42	100	100
	7/3/53	S	31	2.24	7.31	0.13	0.43	79‡	80
		F	30	1.91	6.08	0.13	0.43	67‡	66
		T	32	2.37	6.30	0.13	0.39	83‡	69

* Key: R—raw water; S—settling-basin effluent; F—filter effluent; T—tap water.
† Standard deviation, from Eq 1 (page 979).
‡ These count rates are significantly different from that of raw water at the 2σ level. For the test period Apr. 8–21, for example:

$$\frac{20.70 - 13.08}{[(0.36)^2 + (0.30)^2]^{\frac{1}{2}}} = 16.8 > 2$$

Hence the difference in observed activities cannot be attributed to random fluctuation in counting rates.

* The decay rate of unseparated fission products may be formulated approximately by a hyperbolic equation of the type:

$$A = A_1 t^{-1.2}$$

in which A is the nuclear disintegration rate at time t after detonation; A_1 is the rate at unit time (*6*).

No conversion of count rates (cpm) to disintegration rates ($\mu\mu$c) has been made for the period preceding the Apr. 6, 1953, detonation, inasmuch as the activity during this time represented the residual effects of several antecedent bomb blasts, as well as natural radioactivity, and an exact decay correction could not be made. Calibration measurements for the counting equipment used at Lawrence and Rochester were not available, and no conversion of the count rates to disintegration rates has been made for the data from these plants. The count rates reported refer to activity at the time of measurement. The time lag between collection and counting was usually less than 48 hr.

Also, as another check, most of the Cambridge plant samples were measured a second time on a low-background anticoincidence instrument (*6*), and the uncorrected net count rate data were grouped as before. No important difference in relative passage values was observed.

In all instances, sufficient time elapsed between collection and counting for the count rate of naturally occurring radon and thoron and their daughters to decay to a low value. A large number of measurements were made on various surface waters in eastern Massachusetts in the late summer and early fall of 1952, a period of no reported detonations and of little measured fallout. These measurements gave, on the average, approximately 1 cpm per liter. It is presumed that this activity was predominately Radium D-E and radiopotassium, K^{40}. No correction has been made for natural radioactivity in the net count rates reported.

Cambridge Plant

The Cambridge plant treats 17 mgd of water drawn from a reservoir system having a surface area of 790 acres and a capacity of 3,540 mil gal. Alum, lime, and chlorine are used in this plant, which has flocculation, sedimentation, and rapid sand filtration facilities. A 43-mil gal, open, treated-water distribution reservoir with a surface area of 6.6 acres furnishes water to the distribution system for about 16 hr per week when the plant is inoperative.

Table 2 gives the radioactivity measurements made at this plant during the Nevada test series in the spring and early summer of 1953. The activity recorded as average net count rate from Feb. 9 through Apr. 7 was caused by a small amount of fallout that occurred in this period and by natural radioactivity. It is interesting to note that measurements made in successive periods following the Apr. 7–8 fallout indicated an increasing ratio of the radioactivity of the effluent to the radioactivity of the influent of the plant. Discrepancies between the disintegration rates in the filter plant effluent and tap samples reflect, in part, the absorptive properties of the distribution system and, in part, new activity entering as rain in the open distribution reservoir.

Figure 1 shows the activity changes with time for the various stages in the Cambridge plant. The data are plotted on logarithmic scales so that, in accordance with the hyperbolic formulation (*6*), the decay trends are approximately linearized. The vertical bar through each plotted point represents the 95 per cent confidence zone of the mean of the grouped net counting rates, based on the counting error.

At the top of Fig. 1 is a graph of the estimated radioactive fallout in curies per square mile during the period in which the measurements were made. The rain gage station used in this calculation (Waltham, Mass.) is located near the center of the Cambridge reservoir system, and the radioactivity concentration measurements were made on rain collected at the Harvard University campus in Cambridge. The fallout graph shown is not nearly so accurate as are the data for the relative counts measured in the various stages of the plant during the period of high fallout activity. It is significant that the radioactivity at various stages of the plant had not returned to the pre–Apr. 7 level 2 months after the large fallout. Part of this effect, of course, was due to fallout after Apr. 8, as shown in Fig. 1. It is also interesting to note that, after the third day following the large Apr. 7–8 fallout, the Cambridge rapid sand filters were able to

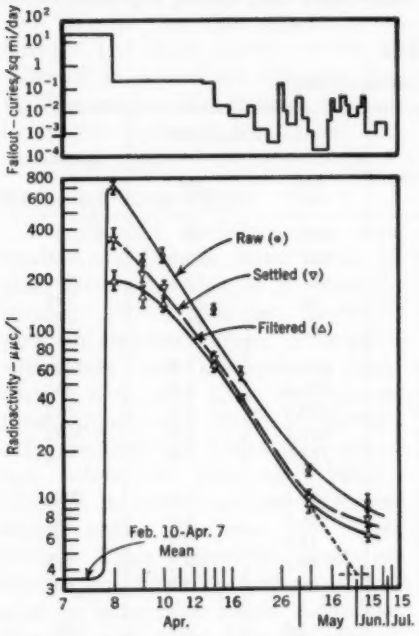

Fig. 1. Radioactivity Curves, Cambridge

The upper graph shows the fallout radioactivity following the Apr. 6, 1953, detonation. The lower graph shows the activities at various sampling points. The predetonation mean activity (24 raw-water samples, Feb. 10–Apr. 7) was 3.51 ± 0.80 μμc per liter.

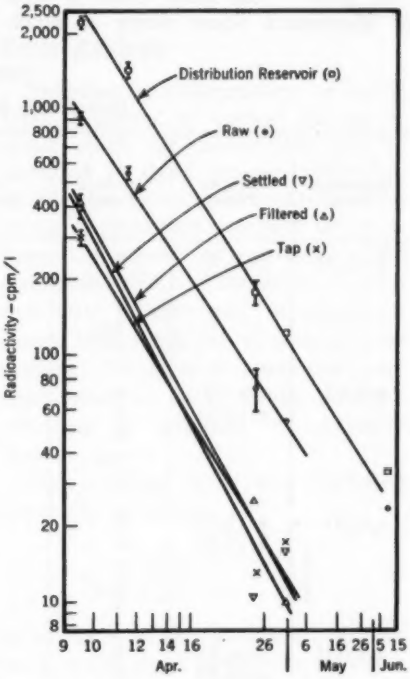

Fig. 2. Decay Curves, Lawrence

The plotted points show the activity remaining in a set of samples collected on Apr. 9, 1953. In the set in question, the open-air treated-water reservoir yielded a higher activity than any of the samples collected at the filter plant.

remove very little of the activity coming from the sedimentation basin.

Lawrence Plant

The watershed of the Lawrence plant also received a large fallout on Apr. 7–8, 1953. This plant treats 8 mgd of Merrimack River water in much the same fashion as the Cambridge plant. Table 3 gives the radioactivity —in counts per minute per liter above background—of the water passing the various stages of the plant.

It is pertinent to note that the count rates in the Lawrence plant following the Apr. 6, 1953, detonation were markedly higher than those at Cambridge. The difference may be attributed partly to the fact that the time lag between collection and measurement of samples was greater at Cambridge than at Lawrence. It has, however, been found that, during a general rainstorm over a large area, a remarkably nonuniform distribution of radioactive fallout may occur. Immediately following the precipitation of Apr. 7–8, 1953, in eastern Massachusetts, the activity in surface waters as measured at 25 sampling stations ranged from 21

TABLE 3

Radioactivity at Lawrence Plant

Detonation Date	Sampling Period	Sampling Point*	No. of Samples	Observed Radioactivity		Relative Activity
				Avg cpm/l	σ† cpm/l	
11/1/51	11/6/51	R	1	369	18	100
		S	1	282	16	77‡
		F	1	92	12	25‡
		Res	1	66	12	18‡
		T	1	71	11	19‡
4/6/53	4/8/53–4/12/53	R	6	410.1	7.0	100
		S	6	226.0	4.9	55‡
		F	6	169.3	4.6	41‡
		Res	6	551.7	5.6	135‡
		T	6	168.0	3.8	41‡
4/6/53	4/13/53–4/17/53	R	5	49.6	3.2	100
		S	5	41.5	3.1	83
		F	5	43.3	3.2	87
		Res	5	35.2	3.1	71‡
		T	5	29.6	3.0	60‡
4/6/53§	4/21/53–6/30/53	R	37	13.0	1.1	100
		S	37	5.7	1.0	43‡
		F	37	6.6	1.0	50‡
		Res	37	5.7	1.0	43‡
		T	36	6.8	1.0	52‡

* Key: R—raw water; S—settling-basin effluent; F—filter effluent; Res—reservoir; T—tap water.
† Standard deviation, from Eq 1 (page 979).
‡ Significant difference from raw-water rate at 2σ level. (See Table 2, last footnote.)
§ Assumed.

to 1,077 cpm per liter, with a mean of 299.

All treated water at Lawrence passes through a 42-mil gal open reservoir, which has a surface area of 7 acres. Four of the daily sets of samples taken after Apr. 7 showed a higher radioactivity for the effluent of this reservoir than for the plant effluent or influent. The decay curves of the set collected on Apr. 9 are shown in Fig. 2. The vertical bars through the plotted points represent the 95 per cent confidence zones.

Rochester Area Plant

The 38-mgd Rochester area plant treats Lake Ontario water taken 1.5 miles from shore and 55 ft below the surface. Alum, soda ash, bentonitic clay, and chlorine are used in the plant, which has both mechanically backwashed slow sand filters and conventional rapid sand filters in parallel. (No chemicals are added for coagulation before the slow sand filters.) There is no open reservoir for treated water, unlike Lawrence and Cambridge. Table 4 gives the counts per minute per liter for various periods after an appreciable fallout in the lake. Samples were taken from the raw influent, the sludge blanket of the solids-contact process basin, the slow sand filter backwash water, the slow sand filter effluent, the rapid sand filter effluent, and the distribution system after the effluents from the two treatment processes had been combined.

The fallouts causing the increases in lake water radioactivity occurred on Nov. 1, 1951, and Jun. 4–5, 1952, and were probably due to the Nevada detonations of Oct. 28 and 30, 1951, and Jun. 1, 1952, respectively. The count rates were significantly greater in the sludge and backwash samples than elsewhere, indicating the extent to which activity is accumulated and concentrated during coagulation and filtration. Sludge samples should yield valuable information in routine monitoring operations.

Error Analysis

Precision of measurement of count rates is limited by several sources of error, which, for convenience, may be classified in three groups: collection, sample preparation, and counting. The counting procedure provided the most important source of variance. The cumulative effect of the errors is such that little reliance may be placed on results from single sets of samples from a plant. When several sets are averaged, however, as in Tables 2–4, the precision is adequate to delineate trends.

The counting error was evaluated using the formula:

$$\sigma_e = \frac{1}{n}\left[\sum_1^n \frac{r_{s+b}}{t_{s+b}} + \frac{r_b}{t_b}\right]^{\frac{1}{2}} \quad \ldots\ldots(1)$$

in which σ_e is the standard counting error of the mean of the n count rates in each group; r_{s+b} is the counting rate of the sample with background; t_{s+b} is the total time the sample with background was counted; r_b is the counting rate of the background alone; and t_b is the total time the background alone was counted.

At both Lawrence and Cambridge the sample radioactivity measurements were alternated with background measurements. Automatic sample-changing equipment was used, and at least 1,024 counts were cumulated for each sample and each background. The samples

TABLE 4

Radioactivity at Rochester Area Plant

Sampling Period	Sampling Point*	No. of Samples	Observed Radioactivity		Relative Activity
			Avg cpm/l	σ_d† cpm/l	
3/16/51–10/31/51	R	39	0.70	0.076	100
	SI	37	31.5	1.3	4,500‡
	B(SS)	37	3.75	0.32	535‡
	F(SS)	39	0.44	0.074	63‡
	F(RS)	38	0.40	0.073	57‡
	T	38	0.55	0.076	79‡
11/1/51–11/15/51	R	12	12.3	0.040	100
	SI	11	1,390	17	11,400‡
	B(SS)	12	205	2.8	1,660‡
	F(SS)	12	4.53	0.30	37‡
	F(RS)	11	4.32	0.32	35‡
	T	12	5.33	0.30	43‡
11/16/51–1/1/52	R	31	0.89	0.087	100
	SI	24	65.0	2.56	7,300‡
	B(SS)	30	22.1	0.64	2,470‡
	F(SS)	30	0.51	0.11	57‡
	F(RS)	24	0.38	0.13	43‡
	T	31	0.71	0.11	80
1/2/52–6/3/52	R	81	0.44	0.057	100
	SI	58	24.2	1.2	5,500‡
	B(SS)	81	3.20	0.24	728‡
	F(SS)	78	0.45	0.06	102
	F(RS)	59	0.32	0.068	73
	T	81	0.35	0.058	80
6/4/52–6/20/52	R	15	3.72	0.17	100
	SI	11	387	6.0	10,400‡
	B(SS)	14	48.8	1.00	1,310‡
	F(SS)	15	1.45	0.15	39‡
	F(RS)	12	1.76	0.17	47‡
	T	15	1.26	0.17	33‡
6/21/52–7/20/52	R	7	1.29	0.21	100
	SI	6	63.8	4.3	4,950‡
	B(SS)	7	13.6	0.98	1,060‡
	F(SS)	7	1.08	0.20	84
	F(RS)	6	0.61	0.21	47‡
	T	7	0.88	0.20	68‡
7/21/52–11/1/52	R	29	0.352	0.10	100
	SI	25	20.4	1.8	5,790‡
	B(SS)	29	2.40	0.29	682‡
	F(SS)	29	0.47	0.10	134
	F(RS)	23	0.47	0.11	134
	T	29	0.50	0.10	142

TABLE 4—*Radioactivity at Rochester Area Plant (contd.)*

Sampling Period	Sampling Point*	No. of Samples	Observed Radioactivity		Relative Activity
			Avg cpm/l	σ_t† cpm/l	
11/2/52–	R	26	0.26	0.10	100
2/1/53	Sl	23	22.0	2.0	8,500‡
	B(SS)	26	2.25	0.43	870‡
	F(SS)	26	0.31	0.10	119
	F(RS)	23	0.39	0.11	150
	T	26	0.40	0.11	154
2/3/53–	R	14	0.54	0.14	100
3/20/53	Sl	14	21.2	2.5	3,920‡
	B(SS)	14	2.60	0.48	482‡
	F(SS)	14	0.26	0.14	48
	F(RS)	14	0.66	0.15	122
	T	14	0.37	0.14	69
1/2/53–	R	37	0.398	0.072	100
5/12/53§	Sl	36	10.2	0.62	2,560‡
	B(SS)	37	2.53	0.30	635‡
	F(SS)	36	0.293	0.075	74
	F(RS)	36	0.528	0.077	133
	T	37	0.302	0.075	76
5/15/53–	R	8	0.53	0.16	100
6/12/53§	Sl	8	40.1	1.62	7,560‡
	B(SS)	9	7.62	1.06	1,440‡
	F(SS)	8	0.59	0.16	112
	F(RS)	8	0.69	0.16	130
	T	8	0.59	0.16	111

* Key: R—raw water; Sl—sludge blanket of solids-contact process basin; B(SS)—slow sand filter backwash water; F(SS)—slow sand filter effluent; F(RS)—rapid sand filter effluent; T—tap water.
† Standard deviation, from Eq 1.
‡ Significant difference from raw-water rate at 2σ level. (See Table 2, last footnote.)
§ Measured at different laboratory from other Rochester sample groups.

from the plant in the Rochester area were changed manually, and background was counted each day, usually for half an hour or more. The standard deviations given in Tables 2–4 were computed from Eq 1 and pertain only to counting error.

The raw-influent count rates from each of the three plants for periods during which the samples exhibited no appreciable trends in radioactivity were used to get the ratio of all the errors to the counting error alone. The standard error of each of these sample groups was computed from the formula:

$$\sigma_t = \sqrt{\frac{\sum (r - \bar{r})^2}{n(n-1)}} \quad \ldots\ldots (2)$$

in which σ_t is the standard error of the group mean due to all types of errors; n is the number of samples; r is the net count rate of each sample; and $\bar{r}$ is the mean of the net count rates of the group. For these groups the standard counting error of the mean of the group was obtained using Eq 1.

Then, by dividing σ_t by σ_c, a Lexis type ratio was obtained. Table 5 gives these values for the various plants.

It may be seen from this table that the counting error was the major factor limiting reproducibility of results. The Cambridge data had the smallest errors. It is believed that, in following radioactivity trends in soft eastern waters at levels 1–100 times those due to natural activity, the technique used at Harvard (1-liter samples; 1,024 counts per sample) represents a reasonable balance of the time and effort expended in sample preparation and counting against the precision attained.

TABLE 5

Error Analysis

Item	Cambridge Plant	Lawrence Plant	Rochester Area Plant
Sampling period	4/21/53–6/30/53	4/21/53–6/30/53	11/4/52–3/20/53
No. of samples	36	29	40
Standard error			
Total, σ_t (Eq 2)	0.180	1.75	0.302
Counting, σ_c (Eq 1)	0.135	1.07	0.321
$\frac{\sigma_t}{\sigma_c}$	1.33	1.64	0.942

With larger samples, such as were used at Rochester, self-absorption of radiation in the solid residue becomes a limiting factor; with smaller samples, like those at Lawrence, reproducibility is limited by the low disintegration rates obtained. The measurements at Rochester were made primarily for monitoring, and, with the relatively short counting times used, the precision attained was satisfactory for the purpose.

Other Investigations

An investigation reported by Straub (*7*) at the Oak Ridge National Lab. (ORNL) showed a passage of only 27–30 per cent of influent radioactivity at a pilot plant having coagulation, sedimentation, and filtration facilities and using alum, lime, and sodium silicate. Instead of actual fallout material, the radioactivity source was pile-produced "fission products mixed to simulate conditions after a bomb blast, but with increased percentages of radioactive ruthenium, iodine, and strontium, which are hard to remove" (*7*). Other studies (*8, 9*), based largely on theoretical considerations, have resulted in estimates of treatment plant efficiencies much greater than those found by the present authors.

It is of significance that none of the passage percentages ("relative activity") in Tables 2–4 are as low as those reported by Straub. This fact is not surprising, for it is very unlikely that the ages of the radioactive substances used at the ORNL were similar to those of the detonation debris in the present investigation. Fallout measurements were made at the Cambridge plant from approximately 2 days to 3 months after fission. During this period the nuclear species causing most of the radioactivity of fission products change often because of different decay rates and radioactive-daughter production. Moreover, during runoff from land surfaces and storage in reservoirs, self-purification results in a selective removal of certain isotopes from the fallout material, so that the response of the mixture to treatment is altered.

Other differences between the fallout and the pile-produced materials may derive from variations of fission rate and temperature in the processes by which they are created. Whereas the ORNL fission products were probably in ionic or radiocolloidal form.

there is ample evidence to show that long-range fallout is, at least partially, in the form of discrete particles. The particulate composition of the fallout is illustrated in Fig. 3, a radioautograph of the solids from 22 liters of rain collected at Harvard.

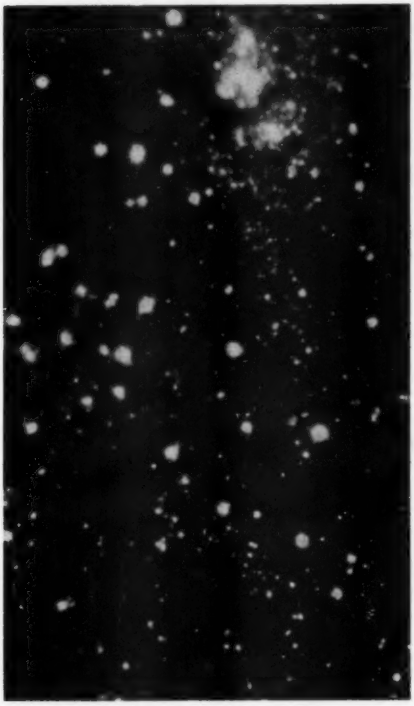

Fig. 3. Radioautograph of Fallout

At Harvard University, 22 liters of rain water was collected and evaporated. The residue was kept in contact with Type K X-ray film for 6 weeks. The resulting radioautograph illustrates the particulate composition of the fallout.

Hursh (*10*) measured the natural radium (Ra^{226}) content of raw and tap water samples from 42 public water supplies in the United States. For 29 plants with flocculation, sedimentation, and filtration, the mean radium passage (ratio of concentration in tap water to that in plant influent) was 58 per cent, with a standard deviation of 31 per cent. The product moment coefficient of correlation between the percentage passage of radium and the concentration of radium in the raw water is -0.72. The probability is 95 per cent that the true coefficient lies between 0.47 and 0.84. This indicates that a high radium content in the raw water is associated with high removal in treatment, which, in turn, suggests that the radium is associated with suspended matter in the water. For eleven supplies with no treatment other than chlorination, the mean ratio of the radium concentration in the tap water to that in the raw water was 72 per cent, with a standard deviation of 47 per cent. Although the same factors did not necessarily operate, this value is in accord with those results in Tables 2–4 that indicate low removal efficiencies during periods remote in time from bomb test programs.

Comparison With Tolerance Levels

As an operational guide in evaluating health hazards due to dispersal of radioactivity from continental weapons tests, the AEC has used the following criterion: to determine whether radioactivity measured in water at any time after fallout is safe, the activity value observed is extrapolated to the value it would have at 3 days after fission, by the "1.2 decay law" previously mentioned; if the extrapolated value is less than 5,000 $\mu\mu$c per milliliter, the water may be used safely for any length of time.

For the Cambridge data, the plant effluent activity at 3 days (Fig. 1) is 0.175 $\mu\mu$c per milliliter or $\frac{1}{2900}$ of the foregoing estimated safe upper limit of concentration. The safety factor is increased to 34,000 if a comparison is made of the actual and safe total exposure in the time interval between 40 hr (the travel time from Nevada) and 55 days following the blast, when the activity had fallen close to the natural level. The cumulative exposure for this period, calculated from the plant effluent curve of Fig. 1, was 1.24 $\mu\mu$c-days per milliliter. The safe exposure by the AEC criterion may be calculated from the integral:

$$5{,}000\ (3)^{1.2} \int_{1.67}^{55} t^{-1.2}\, dt$$

$$= 42{,}800\ \mu\mu\text{c-days/ml}$$

Accordingly, the safety factor is 42,800 $\div$ 1.24 = 34,000. The higher safety factor of the latter computation stems from the fact that the actual disappearance of activity in the water supply proceeds at a faster rate than that given by the 1.2 law.

The safety factor for the Lawrence effluent during the same period is estimated at 1,500–2,000. It should be pointed out that, in special local circumstances, the health hazards may not be as remote as the foregoing impressive safety factors would appear to indicate. Some New England cisterns filled with rain on Apr. 7–8, 1953, are likely to have collected much more fallout than was found in the water that went to the consumers at Cambridge and Lawrence. Of twelve rain samples taken at various stations in eastern Massachusetts, during and after the storm, four showed 3-day activities in excess of 500 $\mu\mu$c per milliliter (10 per cent of the safe value). The highest activity of any sample was 1,970 $\mu\mu$c per milliliter.

It is of interest to note that the highest activity in surface water samples collected near the test site in Nevada during the spring 1953 detonation series was only one-sixtieth of the level of 5,000 $\mu\mu$c per milliliter at 3 days (*11*).

An accurate assessment of the health hazards associated with the presence of fallout in municipal water supplies cannot be based upon measurement of gross beta-gamma radiation, but requires a radiochemical analysis of the amounts of specific isotopes that resist self-purification and plant treatment processes. An investigation of this type is currently being undertaken at Harvard.

Summary and Conclusions

Approximately 2,200 samples taken in the various treatment stages of three water plants were measured for beta-gamma radioactivity. All plants employed alum coagulation and rapid sand filtration. The respective water sources were a system of small reservoirs, a river, and Lake Ontario. From these measurements, which are summarized in Table 6, it was found that, within about 2 weeks after a nuclear detonation, approximately 45 per cent of the gross long-range fallout radioactivity entering passed completely through rapid sand filtration plants. From 2 to 10 weeks after detonation about 53 per cent passed through the plants. For periods beginning at least 10 weeks after detonation, practically all the radioactivity (partially of natural origin) passed through the plants. In every instance, the removal efficiencies were

lower than those reported in pilot scale plants with simulated fission product mixtures.

No measurement of radioactivity made in the investigation to date has the ability of conventional water treatment plants to remove fallout radioactivity, and will encourage municipalities and state health departments to make similar investigations. Much

TABLE 6

Summary of Filter Plant Radioactivity

Sampling Point*	Cambridge, Mass. (Reservoir System)			Lawrence, Mass. (Merrimack R.)			Rochester, N.Y., Area (L. Ontario)		
	No. of Sample Sets	Net Count Rate *cpm/l*	Relative Activity	No. of Sample Sets	Net Count Rate *cpm/l*	Relative Activity	No. of Sample Sets	Net Count Rate *cpm/l*	Relative Activity
First 2 wk After Large Fallout									
R	9	20.7	100	11	246	100	24	7.55	100
S	9	13.1	63	11	142	58			
F(SS)							24	2.82	37
F(RS)	9	10.4	50	11	112	45	24	2.98	40
Res				11	317	129			
T				11	105	43	24	3.07	41
2–10 wk After Large Fallout									
R	50	3.48	100	36	13.0	100	30	0.96	100
S	50	2.61	75	36	5.7	43			
F(SS)							30	0.60	62
F(RS)	50	2.24	64	36	6.6	50	30	0.44	44
Res				36	5.7	43			
T	50	2.73	78	36	6.8	52	30	0.74	77
More Than 10 wk After Large Fallout									
R	13	1.27	100				141	0.45	100
S	13	1.34	105						
F(SS)							141	0.43	96
F(RS)	13	1.57	124				141	0.38	85
Res									
T							141	0.43	96

* Key: R—raw water; S—settling-basin effluent; F(SS)—slow sand filter effluent; F(RS)—rapid sand filter effluent; Res—Reservoir; T—tap water.

exceeded the emergency levels set for radioactivity in water containing bomb fission debris.

It is hoped that the data and techniques presented in this paper will provide a basis for a further evaluation of of the same equipment and many of the techniques should be applicable to measurements of radioactivity whether caused by fallout, reactor wastes, accidental spills into surface water supplies, or contamination due to sabotage.

Acknowledgment

The work at Harvard University was part of a project sponsored by the Atomic Energy Commission. Particular acknowledgment is due Arthur E. Gorman, San. Engr., AEC Eng. Div., Washington, D.C., who suggested the study of long-range fallout. His perspective has been most valuable.

Appreciation is expressed to Jane Maclachlan for her substantial contribution in preparing and counting the Cambridge samples, and to William H. McGinness and David H. Turcott of the Cambridge filtration plant for supervising the collection of samples there.

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A Decade of Fluoridation

By W. L. Harris

A contribution to the Journal by W. L. Harris, Supt., Dept. of Water & Light, Grand Rapids, Mich.

EVER since its inception in January 1945, fluoridation of public water supplies for the reduction of tooth decay has been debated privately and publicly with varying degrees of heat. Public interest was natural because the subject has a direct bearing on everyone, young and old. There was no middle ground on the subject—one was either for fluoridation or against it. This report will briefly review the thinking and controversy attendant upon the establishment of fluoridation as an accepted practice. Although all of the shouting has not yet died out, it must be recognized that, with fluoridation being used by more than 1,000 communities and serving more than 18,000,000 people, the practice can be called established.* Opposition to fluoridation still exists and probably will continue to exist, but it is evident that the overwhelming professional evidence in support of the process, its endorsement by all prominent national and state dental, medical, and public health organizations, and the growing number of favorable legal decisions have led to a gradual lessening of the attack.

Between 1945 and 1949 the water works industry debated the propriety of adding to a public water supply a chemical not intended for the purpose of promoting its safety, clarity, or palatability, or for removing undesirable constituents that would cause corrosion, hardness, or staining. The addition of fluoride was admittedly for an entirely different purpose—the partial control of dental decay—and, to many water works men, adding a nontreatment chemical was considered almost sacrilege. The controversial phrase, "mass medication," became popular as a description of fluoridation. Other vehicles for fluorides, such as salt and milk, were considered and advocated. These discussions in the water industry tapered off somewhat after May 1949, when the AWWA Board of Directors adopted a recommended policy and procedure (*1*). The Board at that time officially accepted fluoridation as a procedure in water treatment practice, provided the responsible state and local authorities approved it.

In 1945, and for a few years thereafter, fluoridation was on trial by professionals. The question to be answered was whether it would reduce dental decay as natural fluorides did. Until 1950 there was a tendency on the part of many health officials to advocate a "wait and see" attitude. Thus, the number of towns starting the treatment during this period was held to a minimum. Only six towns began fluoridation in 1946, the first year after its inauguration. Two followed in 1947, seven in 1948, fifteen in 1949, and 45

* On Aug. 12, 1954, Osawatomie, Kan., became the thousandth community to have a fluoridated water supply.

in 1950. Early in 1950, after only 5 years of fluoride application, the US Public Health Service reported that the Grand Rapids, Mich., fluoridation experiment was showing striking reductions in dental decay in children aged five through seven. (Prior assumptions were that it would take 10–12 years to establish any benefits.) This report was the first positive indication that the program had definite prospects of success. With that knowledge, many communities that had been holding back were convinced. In 1951 a total of 162 towns instituted fluoridation; in 1952, 207; and in 1953, 395.

TABLE 1

*Fluoridation Discontinued**

City	Pop.
†San Diego, Calif.	434,927
†Mount Dora, Fla.	3,039
†Knoxville, Iowa	7,604
†Wakeeney, Kan.	2,446
‡St. Martinville, La.	4,604
†Hudson, Mass.	8,211
†Northampton, Mass.	28,998
†Williamstown, Mass.	2,900
†Tecumseh, Mich.	4,020
‡Akron, Ohio	285,000
‡Sweetwater, Tex.	13,580
‡Tyler, Tex.	38,864
‡Kennewick, Wash.	10,085
‡Delavan, Wis.	4,007
‡Elroy, Wis.	1,646
†La Crosse, Wis.	47,396
†Stevens Point, Wis.	16,550
†Sheridan, Wyo.	11,400

* In addition to the cities listed, three cities—Naples, Fla.; Assumption, Ill.; and Minneapolis, Kan.—discontinued fluoridation but later reinstated it.
† By referendum.
‡ By governing body.

Opposition Campaign

In 1945, when Grand Rapids, Mich., Newburgh, N.Y., and Brantford, Ont., inaugurated fluoridation in the United States and Canada, there was no organized opposition to the program. The idea apparently was so new that its opponents had not had time to gather their forces and develop a line of attack. By 1951, however, the real fury of the opposition was beginning to be felt in an avalanche of printed material, including brochures, letters to the editor, newspaper stories, mimeographed reproductions of adverse statements on the subject, and articles in national magazines. Much of this material used fear as an instrument of mass propaganda. The few scientifically trained persons who raised their voices objectively to advocate caution were soon being misquoted and made to appear arch-opponents of fluoridation. Everyone was being told that fluoride was rat poison; that the program was a Communist plot; that it was promoted to aid the aluminum "interests"; that, although "organic" fluoride (presumably "natural" fluoride) was not harmful to the user, "inorganic" fluoride (applied fluoride) was a distinct hazard; that fluoridation was "mass medication" or "socialized medicine"; that fluoridation would increase cancer, nephritis, heart disease, cirrhosis of the liver, and intracranial lesions; that the use of fluoridated water would cause brain damage and probably result in feeblemindedness; that fluorides were very corrosive to metal pipes; that the US Public Health Service was promoting a scheme that conceivably might turn out to be an instrument of race suicide; that fluoridation was a weapon for saboteurs; that mechanical failure of fluoride-feeding equipment might destroy the community; that fluoride would make the bones brittle; that it would break down the "will" of the people; that fluoridation was responsible for greatly increased automobile accident rates; and, finally, that fluoridation was uneconomical.

The height of the opposition campaign may have been reached in 1953, as there has since been a definite abatement in the number of circulars received. The campaign was directed at the uninformed or partially informed public, which may usually be counted on to react strongly to scare literature. Thus, the objective of the opponents was to have the decision on fluoridation made by public referendum rather than by the city council. How such a plan managed to defeat fluoridation in one town (Williamstown, Mass.) is well described by J. A. Hutchinson (*2*). A similar experience, but with a reverse result, is related by Leo Louis (*3*), regarding Cedar Rapids, Iowa.

The opposition campaign undoubtedly had some effect on the fluoridation program, but accurate statistics are not available. In many communities, the opposition caused the proponents of the program to become more active and to work harder to sell fluoridation to the people by means of educational programs. In some towns, the residents were sharply divided on the issue.

TABLE 2

Fluoridation Approved by Referendum

City	Pop.	City	Pop.
Belmont, Calif.	5,548	Seekonk, Mass.	6,087
Hayward, Calif.	14,273	Sharon, Mass.	4,847
Healdsburg, Calif.	3,330	Shrewsbury, Mass.	10,392
Martinez, Calif.	8,216	Templeton, Mass.	4,502
Pleasanton, Calif.	2,245	Topsfield, Mass.	1,409
San Francisco, Calif.	827,400	Albion, Mich.	10,395
Cordele, Ga.	9,642	Battle Creek Twp., Mich.	50,000
Valdosta, Ga.	20,004	Charlevoix, Mich.	2,695
Waycross, Ga.	18,842	Colon, Mich.	1,002
Lexington, Ill.	1,173	Lakeview, Mich.	824
Rockford, Ill.	92,503	Sault Ste. Marie, Mich.	17,750
Bar Harbor, Me.	3,864	Amboy, Minn.	576
Belfast, Me.	5,960	Perth Amboy, N.J.	41,291
Bridgton, Me.	2,950	Monticello, N.Y.	4,237
Brunswick, Me.	10,996	Astoria, Ore.	12,331
Bucksport, Me.	3 120	Bend, Ore.	11,347
Ellsworth, Me.	3,936	Corvallis, Ore.	16,173
Jay, Me.	3,102	Florence, Ore.	1,026
Livermore Falls, Me.	3,359	Greenville, S.C.	57,932
Norway, Me.	2,687	Spartanburg, S.C.	32,249
Scarboro, Me.	4,600	Rapid City, S.D.	25,179
South Paris, Me.	4,358	Bennington, Vt.	8,002
Winslow, Me.	4 413	Pomeroy, Wash.	1,769
Athol, Mass.	11,540	Berlin, Wis.	4,693
Essex, Mass.	1,795	Eagle River, Wis.	1,469
Hingham, Mass.	10,694	Gillett, Wis.	1,410
Hudson, Mass.	8,211	Mellen, Wis.	1,300
Hull, Mass.	1,500	Milwaukee, Wis.	720,429
Medway, Mass.	3,744	Oconomowoc, Wis.	5,322
North Andover, Mass.	8,429	Pewaukee, Wis.	1,784
Rockport, Mass.	4,180	West Allis, Wis.	42,945
Scituate, Mass.	1,457		

One measure of the effect of opposition activity is the number of communities that discontinued fluoridation after having practiced it for a relatively short period. Table 1 lists these cities by name. It should be noted that three towns which had discontinued fluoridation later reinstated it.

Records up to Dec. 31, 1953, indicate that 115 towns held referendums to decide on fluoridation. Sixty-three communities, with a total population of 2,159,438, approved fluoridation, while 52 others, with a population of 1,789,404, rejected it. Tables 2 and 3 list the towns involved.

Court Action

Another avenue of attack on fluoridation was through the courts, which were asked to make decisions on such questions as: Would fluoridation subject the people to mass medication? Would it invade their rights of religious freedom? Was it unduly harsh and oppressive in the absence of an emergency? Was it a valid health measure if there were no epidemic and the program would not prevent contagion or infection? Did the local town council have the right to order fluoridation? Did fluoridation violate the Federal Food, Drug, and Cosmetic Act? Was fluoridation in violation of state statutes dealing with the practice of medicine, dentistry, and pharmacy? Was the action of a city in ordering fluoridation an unconstitutional invasion of the right of every parent to bring up his children as he might deem proper?

During 1952 the first court decisions on the subject were reached. These cases related to Northampton, Mass.; San Diego, Calif.; Chehalis, Wash.; Baltimore; and Fargo, N.D. Land and Mosenthal (*4*) summarized the opinions of the courts as follows:

Assuming that the consumption of fluoridated water is contrary to the religious beliefs of certain persons, and avoiding the debatable question whether consumers of municipal water are entitled to have the water remain free from particular substances which do not render it impure or unwholesome, there is very little legal authority on the particular issue. Most of the older cases on freedom of religion involved criminal sanctions for doing or failing to do certain acts. As a legal matter, persons are not required to drink water from the city water supply, although, as a practical necessity, they may be forced to. The element of compulsion by the state or local government is lacking. The decisions reviewed show that the courts are reluctant to base their opinions on this ground, or on the ground that the plaintiffs lack standing to raise the constitutional issue.

Based on the foregoing court decisions and the other available legal authorities, the only possible conclusion is that, upon compliance with local law, there is no legal obstacle to adopting and carrying out a fluoridation program. For this reason, it would appear that the decision of a legislative body on the matter is controlling and that the desirability of initiating or continuing fluoridation of a public water supply can properly and usefully be argued only before the local governing body.

Since 1952 other cases before the courts have resulted in opinions favorable to the advocates of fluoridation. The towns involved were: Greenville, S.C.; Milwaukee, Wis.; Tulsa, Okla.; Cleveland, Ohio; and Bend, Ore. At Shreveport, La., a court granted an injunction against the enforcement of the council resolution ordering fluoridation, but the state supreme court reversed the lower court's decision. In Ohio and Oklahoma, higher courts have upheld lower-court decisions favorable to fluoridation. Appeals to higher courts

TABLE 3

Fluoridation Rejected by Referendum

City	Pop.	City	Pop.
Carmel, Calif.	4,321	Three Oaks, Mich.	1,567
Cloverdale, Calif.	1,278	Hibbing, Minn.	16,212
Glendale, Calif.	95,398	South St. Paul, Minn.	15,996
Lodi, Calif.	13,727	Virginia, Minn.	12,332
Monterey, Calif.	16,120	Indianola, Miss.	4,384
Oakdale, Calif.	4,060	Dillon, Mont.	3,079
Pacific Grove, Calif.	9,573	Hornell, N.Y.	15,055
San Bruno, Calif.	12,409	Statesville, N.C.	16,763
San Carlos, Calif.	14,339	Cincinnati, Ohio	500,510
Santa Cruz, Calif.	21,848	Albany, Ore.	10,076
Santa Maria, Calif.	10,402	Hillsboro, Ore.	5,122
Santa Rosa, Calif.	17,905	Saluda, S.C.	1,589
Daytona Beach, Fla.	29,254	Littleton, Vt.	500
Tallahassee, Fla.	27 158	Cashmere, Wash.	1,750
Durand, Ill.	592	Rosalia, Wash.	596
Freeport, Ill.	22,425	Seattle, Wash.	462,440
Mount Pulaski, Ill.	1,522	Brandon, Wis.	708
McPherson, Kan.	8,659	Burlington, Wis.	4,774
Ayer, Mass.	5,728	Hudson, Wis.	3,436
Braintree, Mass.	23,130	Manitowoc, Wis.	66,607
Manchester, Mass.	2,033	New Richmond, Wis.	2,869
Needham, Mass.	16,262	Park Falls, Wis.	2,933
Flint, Mich.	162,800	Plymouth, Wis.	4,540
Iron Mountain, Mich.	9,578	Sauk City, Wis.	1,750
Lansing, Mich.	91,694	Shawano, Wis.	5,869
Lowell, Mich.	1,944	Viroqua, Wis.	3,788

have also been made in Oregon and North Dakota. It is of interest that the US Supreme Court, in June 1954, refused to interfere with previous California court decisions upholding San Diego's legal right to fluoridate its water supply.

Court action was started at Peekskill, N.Y., to enjoin the board of water supply from undertaking fluoridation. The court held that state legislation was necessary to enable the board to take such action. An enabling act had been passed by the legislature in 1953 but was vetoed by the governor, who held that the city council had full authority in the matter.

An injunction has been brought against the city of Fulton, N.Y., to require it to cease fluoridating the municipal water supply. The stipulated facts presented in evidence were held to be inadequate, and the case has been placed on the calendar of the state supreme court.

The record of court action to date may be summarized in the statement that the power of a municipality to fluoridate its water supply has been upheld by the courts, wherever challenged.

Legislation and Legislative Investigations

The opponents of fluoridation have also sought to retard or prevent the success of the program through state and federal legislation. Numerous bills

have been introduced into state legislative hoppers during the past 3 years, but no state has enacted a law opposing fluoridation. A bill for that purpose (H.R. 2341, known as the Wier Bill) was also introduced in Congress. The heading describes it as "a bill to protect the public health from the dangers of fluoridation of water." The text of the bill follows:

> *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That no agency of the Government of the United States (including the government of the District of Columbia, and of each territory and possession of the United States), and no agency of any State, or of any municipality or other political subdivision of a State, shall treat any public water supply with any fluoride compound, or make any water so treated available for general use in any hospital, post office, military installation, or other installation or institution owned or operated by or on behalf of any such agency.

A public hearing on the bill was held in May 1954. The weight of the professional evidence against it was so heavy that the measure died in committee.

In 1951 and 1952 the Delaney committee of the House of Representatives, formed to investigate the use of chemicals in food and cosmetics, held public hearings on water fluoridation. The committee's findings, on the basis of which it recommended a cautious approach, were made public in July 1952 and received wide publicity (*5*). The American Dental Assn. strongly attacked this conclusion as not warranted by the facts.

Conclusion

Despite all the contention, the past 10 years have seen the continuous advance of fluoridation. The number of people regularly supplied with artificially fluoridated water jumped from none in the beginning of 1945 to more than 18,000,000 in 1954. With the subject a live one in every community in which the supply is deficient in fluorides, there is every reason to expect that this growth will not only continue but accelerate during the next 10 years.

In closing this brief review of the first decade of fluoridation, a word of commendation must be said for the water works profession, which has carried out and controlled the fluoridation of water supplies for more than 1,000 communities and 18,000,000 people without a single failure or accident.

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Cross-Connection Hazards and Protection

By H. A. Spafford

A paper presented on Mar. 18, 1954, at the Illinois Section Meeting, Chicago, by H. A. Spafford, Chief, Bureau of Gen. Sanitation, State Dept. of Public Health, Springfield, Ill.

THE 40 waterborne epidemics recorded since 1907 in Illinois have resulted in 13,000 known cases of illness and 200 deaths. Eighteen of the epidemics, almost half the total, were caused by some type of faulty piping or plumbing arrangement that permitted sewage or contaminated water to enter a safe water system either at the source or in the distribution facilities. This type of defect resulted in 4,406 cases of illness and 92 deaths, 34 and 46 per cent of the respective totals. Cross connections between safe and raw or unsafe water systems have been the greatest single cause of waterborne epidemics in this period of nearly 50 years.

Cross connections can be classified as direct or indirect. In the former, the safe water system is physically joined to a system containing unsafe water, sewage, or other waste—for example, a fire-fighting system utilizing raw water from a polluted river. In indirect cross connections, contaminated water or waste may be sucked or blown across a space to a safe water system. The most common example of this type of cross connection is found in the ordinary lavatory washbasin, where the water discharge outlet of the faucets may not be elevated sufficiently above the rim of the bowl to prevent siphonage of waste water from it into the water supply pipes. Vacuums can occur in water supply pipes in buildings, especially on the upper floors, at times of peak water usage or during shutoffs for repairs, even though normal pressures prevail in the water mains; moreover, main pressures sometimes fail for various reasons, in spite of the best efforts of water works operators.

The contamination hazard from direct cross connections should be obvious to all water works personnel. Even if pressures are normally high enough to prevent contamination from entering the safe water pipes, this favorable situation may be reversed as a result of mechanical failure, accident, fire demand, leaking valves, human error or ignorance, and scores of other causes. Possibilities for back siphonage through improperly designed or installed plumbing fixtures exist in almost countless numbers in millions of homes, factories, and public buildings. Although the control of plumbing in buildings is ordinarily not a function of water works personnel, they should recognize the magnitude of the problem and render assistance whenever possible. Emphasis should be placed on the importance of maintaining normal pressures in water mains and the need for emergency disinfection following pressure failures.

Water works personnel generally do have some control over direct cross connections between public and industrial water supplies. Many industries,

although producing the bulk of their water requirements from their own facilities, may frequently desire to have the public water supply available for emergency service, especially to obtain lower fire insurance rates. Industries generally prefer a direct cross connection enabling them to secure, at will, municipal water under pressure. There is nothing inherently wrong in a direct cross connection of a public water supply with an industrial water supply, *provided that all parts of the industrial supply are located, constructed, and maintained according to the same sanitary and bacteriological standards as the public supply.* The practical difficulty, however, is to assure the observance of this condition, especially in a large industrial area, where there may be scores or even hundreds of plants with continual alterations in facilities and processes, involving shutoffs and piping changes. Complete and adequate control through inspection by water works personnel or public health authorities is almost impossible physically, even if the terrific burden of expanded responsibility could be borne by these agencies.

The safest policy is to permit no direct physical cross connections between municipal and private water supplies. In large municipalities, there should be no need to deviate from this policy. In some smaller ones, lacking standby facilities, direct cross connection with an *entirely safe* industrial supply might be justified, because it could be of mutual benefit and the added obligation of assuring the continued safety of one industrial supply might not be an impossible burden. If such a cross connection is permitted, the public water supply owners should recognize their increased moral and legal responsibility for maintaining safe water in both systems. Every portion of the cross-connected supply should be considered as an integral part of the public water supply system, with operation, maintenance, and sample collection being conducted in the same manner for both supplies.

In general, there should be no objection to the cross connection of two or more adjacent public water supplies that are of safe sanitary quality. In fact, such interconnections might be encouraged, especially for civil defense purposes.

Methods of Protection

The only universally acceptable safe method of furnishing water from a public supply to a consumer who also maintains a private supply is free-fall discharge, usually from a separate riser pipe above the top of a privately owned elevated tank, to save repumping. Free-fall discharge over a ground surface reservoir or sump gives equal protection to the public supply but requires repumping. A minimum free-fall distance equal to two pipe diameters is the standard established after repeated tests by reputable hydraulic and plumbing laboratories.

A backflow preventer intended for use on direct cross connections has been developed in recent years. The mechanism consists essentially of two spring-loaded check valves, with a spring-loaded, hydraulically operated bleeder valve mounted between them. The check valves are spring loaded to the closed position, while the bleeder valve is lightly spring loaded to the open position. If the device is correctly installed and does not fail mechanically, it is capable of preventing backflow. Despite precision of construction and proper selection of ma-

terials, it is subject to failure due to broken springs, frozen valves, or obstructions lodged under the valve seats. Consequently, assurance of protection depends on frequent and vigilant inspections. To some degree, this requirement also applies to vacuum breaker installations (to be described below), now universally accepted as reasonable protection on certain plumbing fixtures requiring direct water connections.

The backflow preventer for direct cross-connection protection has, to date, received only limited approval by a few authorities. It is probable that, at least for some uses, acceptance will increase in time, as longer histories of existing installations become available. Certainly, the employment of a backflow preventer, even without proper inspection, is better than leaving a direct cross connection entirely unprotected. It must be emphasized, however, that the only known method of obtaining complete protection is free-fall discharge, or, in effect, no cross connection at all.

Many cross connections exist between public water supplies and private wells and cisterns in homes, especially in small communities and localities where public water service may have only recently been provided. Most private water supplies in built-up areas are unsafe or of doubtful sanitary quality because of their proximity to sewers, septic tanks, and similar sources of dangerous contamination. All interconnections involving such supplies and municipal water systems should be broken by removing a piece of pipe and physically severing the two systems. Municipalities should prohibit such connections by ordinance, and water works personnel, particularly meter readers, should be alerted to detect violations.

Water Works Installations

At water works facilities themselves, there are some possibilities of back siphonage over which water works personnel have direct control; toilets, urinals, chemical-feed machines, high-pressure filter wash systems, water-lubricated bearings, and sludge flush-out lines, all of which may be supplied by finished water, are examples. Back siphonage in buildings on the distribution system is hazardous, but its effect is generally confined either to the building where it occurs or to the immediate vicinity. Back siphonage at the water treatment plant, however, can affect the entire system, and it is, therefore, especially important that all cross connections and back-siphonage possibilities in the plant be eliminated.

To avoid these hazards, the delivery of finished water to any point of use—such as a plumbing fixture, chemical feeder, or solution tank—should, wherever possible, be made by employing a free-fall discharge over a distance of at least two pipe diameters above the maximum flood level of the receiving unit. (The maximum flood level is ordinarily the top of a receiving basin, even if an overflow pipe is provided at a lower level.) When free-fall discharge is not possible, an approved vacuum breaker should be properly inserted in the water supply line serving the unit.

A vacuum breaker is a mechanical device installed in a water supply line, so arranged that a drop in water pressure to a point slightly below atmospheric pressure will cause a port to open and permit air to enter. This limits the vacuum that can be created in the water line serving a fixture to a very small negative pressure—only a few inches of water. Each type and

size of breaker must be thoroughly tested by a reputable hydraulic laboratory to assure that it meets certain standards of operation and dependability.

The vacuum breaker must be located at some minimum elevation above the maximum flood level of the receiving unit. This minimum is usually 6 in., but may vary with different makes and sizes of breakers. Approval of each breaker by the testing laboratory includes the determination of the minimum elevation. The breaker must be located on the downstream side of all control and shutoff valves, in order to assure periodic operation of the breaker parts; otherwise, long inactivity may cause the breaker to become stuck in closed position, so that it will fail to open and admit air when a vacuum occurs.

A number of water works facilities where cross connections and back siphonage are frequently found are mentioned briefly below:

Toilets and urinals. Directly connected flush valve types should have a vacuum breaker installed in the water line below the valve and at least 4 in. above the top of the bowl. Gravity tank types should be equipped with a siphon breaker ball cock, installed so that the air inlet of the breaker is at least 1 in. above the top of the overflow tube within the tank.

Chemical feeders. A vacuum breaker should be installed on the water supply line serving the dissolving pot, at least 6 in. above the top of the dissolving basin. All control valves, manual or automatic, must be upstream from the breaker to assure periodic operation of the breaker mechanism. Vacuum

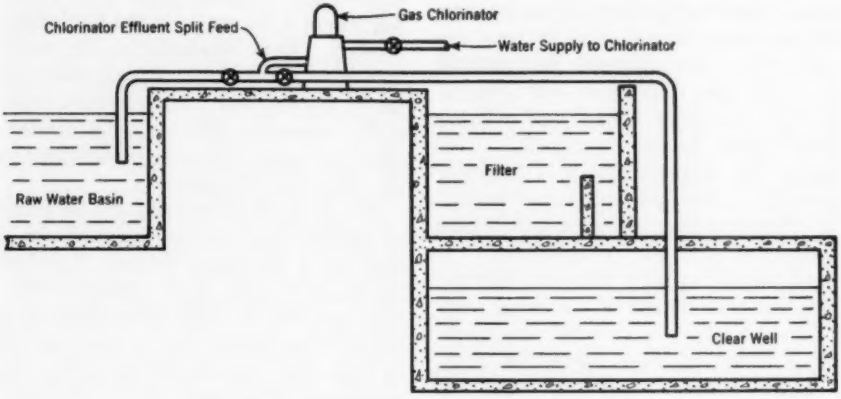

Fig. 1. Hazard of Split-Feed Chlorination

Shutting off the chlorinator transforms the piping into a siphon, which conducts raw water to the clear well. If separate chlorinators cannot be used, the chlorinator effluent should discharge to the raw water by free fall.

breaker protection is particularly important on machines feeding fluorides.

Chlorinators. Chlorinators, especially those feeding to raw or partially treated water, need to be protected. Either the chemical-solution discharge from the machine should have free fall above the top of the receiving basin, or a vacuum breaker should be installed on the water supply line serving the chlorinator. Negative head may occur in filter underdrain systems, resulting in direct siphoning of contamination from the sewer to the clear well. Most filter waste installations are not used and can generally be removed.

Filter waste pipes. Waste pipes, particularly on gravity filters, are hazardous when directly connected to sewers.

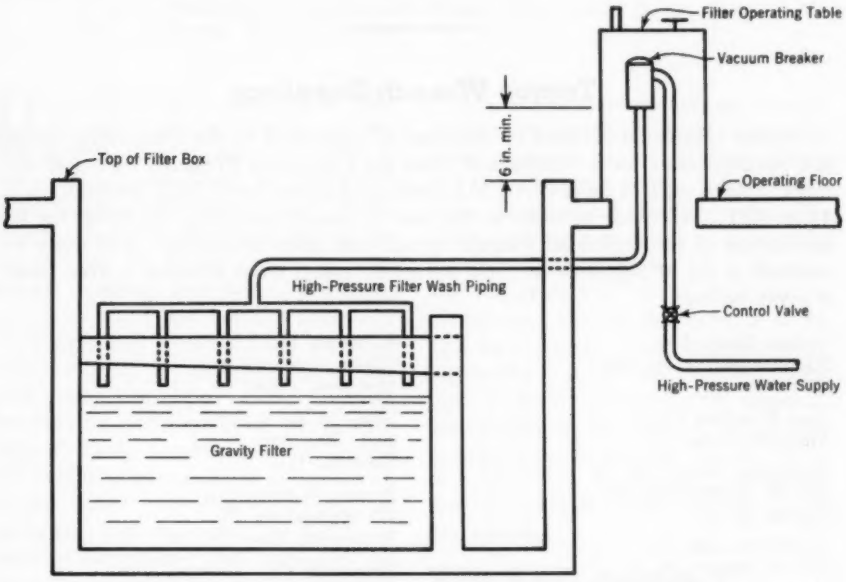

Fig. 2. Vacuum Breaker for High-Pressure Filter Wash Piping

The breaker must be at least 6 in. above the top of the filter box and must be located downstream from the control valve.

The breaker must be 6 in. above the flood level of the chlorinator, downstream from all water control valves. A single chlorinator arranged for split feeding of both raw and finished water is especially hazardous, because it may set up a perfect siphon between the raw-water basin and the clear well (Fig. 1). A vacuum breaker on the water supply line serving the chlorinator may not be effective protection for this dangerous arrangement. If split feed must be used, the discharge to the raw water should be by free fall above the top of the basin, but the best method is to use separate chlorinators.

Pressure filter and ion exchanger wash and rinse pipes. Such piping should not have direct connections to

sewers. Provision should be made for a free fall of at least two pipe diameters above the top of a receiving funnel or sump.

High-pressure filter wash piping. A separate vacuum breaker should be used for each filter. To be effective, the breaker must be 6 in. above the top of the filter box, on the downstream side of the control valve (Fig. 2).

Water-lubricated bearings and sludge flushout lines. If supplied with finished water and subject to submergence in untreated water, such facilities should have vacuum breaker protection. Again, the breaker must be on the downstream side of the control valve and at least 6 in. above the maximum liquid level of the basin in which the finished-water piping is submerged.

Torque Wrench Suppliers

In the "Notes on Method of Installation" appended to the "American Standard Specifications for a Mechanical Joint for Cast Iron Pressure Pipe and Fittings" (ASA A21.11, AWWA C111; published in the April 1953 JOURNAL, Vol. 45, p. 431), reference is made to the use of torque-indicating wrenches for the application of recommended torques to cast-iron bolts in a joint. For those interested, a list of suppliers of such wrenches, taken from *MacRae's Blue Book*, is given below:

Ammco Tools, Inc.
2124 Commonwealth Ave.
North Chicago, Ill.

Apco-Mossberg Co.
Attleboro, Mass.

Armstrong Bros. Tool Co.
5211 W. Armstrong Ave.
Chicago 30, Ill.

Blackhawk Mfg. Co.
5325 W. Rogers St.
Milwaukee 1, Wis.

The Herbrand Corp.
Fremont, Ohio

J. O. Mfg. Co.
South Gate, Calif.

P. & C. Hand Forged Tool Co.
Box 5926, Milwaukie P.O.
Portland 22, Ore.

Reasor Mfg. Co.
St. Charles, Ill.

Richmont, Inc.
922-M S. Myrtle Ave.
Monrovia, Calif.

Snap-On Tools Corp.
8031—28th Ave.
Kenosha, Wis.

Stevens Walden, Inc.
475 Shrewsbury St.
Worcester, Mass.

Sturtevant Co.
Addison, Ill.

Sunnen Products Co.
7954 Manchester Ave.
St. Louis 17, Mo.

Sweeney Mfg. Co.
1601—23rd St.
Denver 17, Colo.

Williams & Co.
400 Vulcan St.
Buffalo, N.Y.

Fundamentals of Water Works Operation

Panel Discussion

A panel discussion presented on Jun. 24, 1954, at the Pennsylvania Section Meeting, Allentown, Pa.

Water Supply—*Lawson D. Matter*

A paper presented by Lawson D. Matter, Asst. Chief Engr., State Dept. of Health, Harrisburg, Pa.

DURING 1953 a total of 39 public water supply systems, serving 500–80,000 people, were reported to the Pennsylvania Dept. of Health as being dangerously low on water. These systems had placed restrictions on the use of water for such purposes as automobile washing and lawn sprinkling, and 21 of them had found it necessary to obtain water from auxiliary or emergency sources to use until the spring rains came, in April 1954. Several learned, for the first time, the advantages of being connected to the system of an adjoining community blessed with ample water. In five instances, the governor was requested to declare a state of emergency and authorize the Pennsylvania civil defense organization to furnish pipe, pumping equipment, and water treatment facilities in order to transport and make safe water from inferior sources of supply for use in the affected communities. A study disclosed that some of these 21 systems had never previously been in trouble due to drought, while a fairly large number had had difficulty before, including several that had suffered water shortages for as many as 5–6 years in succession.

It is evident that numerous Pennsylvania communities are outgrowing their water supply sources. This condition has been brought about chiefly by the rapid development of fringe areas with accompanying population increases, the enormous use of water by industries, and the growth of air conditioning installations. Despite the threat of shortage, many communities have done nothing to obtain additional sources of supply. It seems advisable that responsible officials in the affected areas take prompt steps to provide for the facilities needed to assure their communities of sufficient water during normal dry seasons.

Water Supply Statistics

Pennsylvania, with an area of 45,000 sq miles, has an average annual rainfall of 42 in., which amounts to 33,000 bil gal. If all of this water were available to public systems, one year's rainfall would serve the state for 68 years. Based on Harrisburg, Pa., rates, the sale price of this quantity would be 2.2 billion dollars.

Compared with certain other states in the Union, Pennsylvania is fortunate, in both the quantity of rainfall and its

distribution. Nevada, for example, has an average precipitation of 8 in. per year, and in some other western states 90 per cent of the total annual rainfall occurs in a period of 4–5 days. In Pennsylvania, 60 per cent of the 42-in. annual rainfall is received between January and June, which leaves 40 per cent for the second half of the year, when the so-called dry seasons usually occur. Although approximately 50 per cent of the precipitation is lost through evapotranspiration, the remainder is still many times the estimated consumption of water by man and his activities.

Data collected by the US Geological Survey, in cooperation with state agencies, indicate that, in 1951, public water supply systems in Pennsylvania delivered 1,319 mgd to consumers who constituted 82 per cent of the state's population. Of this quantity of water, 92 per cent was obtained from surface sources and 8 per cent from underground. In addition, private supplies furnished 9,410 mgd, chiefly to industry. Of this amount, 95 per cent was taken from surface supplies. Thus, only about 12 per cent of the demand is furnished by public water supplies. Furthermore, of all the water used in the state, 95 per cent is taken from surface sources.

Surface Supplies

These figures emphasize the extremely important place that surface sources occupy in the Pennsylvania water supply program. This state has taken the lead in the application of pollution control measures to improve the quality of the water in the streams that are now relied upon, and will be utilized still more in the future, as sources of public supplies.

The Schuylkill River is an outstanding example of how a grossly polluted stream can be benefited by an effective pollution control program. As a result of the excellent cooperation of the municipalities and industries along the Schuylkill with the Pennsylvania Sanitary Water Board in the construction of sewage and waste treatment facilities, combined with the silt dredging program of the State Dept. of Forests and Waters, this river has been transformed from an open sewer to a clean stream that supports fish life, in spite of the fact that it flows through one of the greatest industrial areas in the world. This transformation has been of great help to the communities using the river as a source of public supply—especially to Philadelphia, which takes half of its water from the Schuylkill.

The discharge of acid mine wastes in Pennsylvania's streams still constitutes a serious pollution problem, particularly in the bituminous areas. Considerable research has so far failed to provide a practical solution. The presence of acid mine drainage in surface streams very frequently renders them unsuitable as sources of public water supply, thus forcing municipalities located on such streams to look for other sources.

Fortunately, the topography in many sections of Pennsylvania lends itself to the construction of impounding reservoirs on small surface streams, so that water can be stored in times of plenty to meet demands during prolonged periods of drought. Many such reservoirs are in use throughout the state today and perform the service for which they were intended. It is obvious, from the experiences of numerous communities during the 1953

drought, that additional storage would have solved their problems.

Ground Water Supplies

A number of small communities in Pennsylvania obtain their water supply from wells and underground springs. The recent drought proved that many of the so-called unfailing springs can actually fail and clearly indicated the need for developing additional underground sources. There are persistent rumors that ground water levels throughout the state are becoming lower and that eventually the underground supply will be exhausted. The US Geological Survey reports, however, do not substantiate such claims. It is true that there are a few areas in Pennsylvania where ground water levels have receded, but this has usually been the result of heavy localized pumping, particularly in the Philadelphia and Pittsburgh areas. Although ground water sources furnish a comparatively small percentage of the total supply in Pennsylvania, they are important in small communities where it would be financially difficult or physically impossible to treat surface water adequately.

Water Conservation

A survey has disclosed that, when a Pennsylvania community faces a water shortage, the first restriction placed on water consumption usually consists of a ban on lawn sprinkling and car washing. In several instances, industries were closed down temporarily to save water for strictly domestic uses.

In communities with limited sources of supply, the general use of water for air conditioning is a large consumption factor. Several communities have prohibited air-conditioning use in installations that do not provide for recirculation of the water.

Frequently a water waste survey to eliminate leaks has been the margin of safety between an ample supply and the necessity for placing restrictions on use. Too often water works officials seek additional water without attempting to conserve what they already have. Universal metering can reduce waste by an appreciable percentage and extend the ultimate daily capacity of the supply so that it will remain adequate for several years.

Conclusion

Pennsylvania's water resources are known to be abundant and should be able to meet future needs, provided they are conserved for use at the proper time and are properly and fairly allocated and distributed. The wise water works administrator must become aware of the general trend toward increased water use and make his plans accordingly. Where experience has shown that a system does not have sufficient water to supply all of the consumers all of the time, prompt corrective measures are imperative. It is unsound practice to rely year after year on so-called emergency sources of supply, which are often of questionable quality. The state health department will approve auxiliary sources of supply, with appropriate treatment, in real emergencies, but, when the same situation recurs annually, it ceases to be an emergency but instead becomes a habit, and a bad one at that.

Clarification and Filtration—*Martin E. Flentje*

A paper presented by Martin E. Flentje, Research Engr., American Water Works Service Co., Philadelphia.

This paper will review briefly the elements of water clarification and filtration. The earliest effective device for removing turbidity from municipal supplies was the slow sand filter. It required a large filter area, however, and was unable to handle highly turbid water satisfactorily. Pretreatment by plain settling worked in many instances, but it often took too long and the large basins needed were uneconomical to build. Also, surprisingly enough, it soon became apparent that certain fine solids refused to settle out and remained suspended in the water even after extremely lengthy periods of standing.

Coagulation with chemicals solved this problem about 1900. Chemical coagulation, combined with short-period sedimentation, is now employed for the gross removal of suspended matter, while rapid sand filters are used to polish the partially clarified water. The reduction of turbidity from as high as 50,000 to 0.5 ppm is no longer considered an unusual feat.

Coagulation Processes

The formation of floc through the reaction of a coagulating chemical with the alkalinity salts naturally present in water or artificially added, resulting in the subsequent entrapment of suspended dirt and bacteria, is not so simple a process as it appears to be. Improper understanding of it often leads to overdosage and faulty treatment in an attempt to meet coagulation difficulties. A similar observation might be made regarding many of the other processes employed in water conditioning. Well meant efforts to simplify the technology of water treatment have led many operators to believe that only a superficial knowledge of the underlying scientific principles is required.

Stated concisely, the three fundamental considerations in the clarification of water through chemical coagulation are as follows: [1] coagulation cannot proceed without the formation of a floc; [2] coagulation cannot result in clarification unless the floc entraps the suspended matter thoroughly and completely; and [3] coagulation cannot be successful unless the suspended matter is held within the floc particle continuously. Provision must be made to facilitate the chemical reaction between the coagulant and the alkalinity. The coagulant must be thoroughly and quickly dispersed throughout the water to be treated. This aim is often accomplished by one of the many types of flash mixing, in which chemical reactions are extremely rapid—very likely a matter of seconds, even at low temperature. The reaction results in the formation of a precipitate, an insoluble salt like $Al(OH)_3$ but probably not that simple a compound.

When first formed, the precipitate particles are so small that, even if they are attached to the suspended particles in the water, no settling occurs until further agglomeration results. Therefore, it is necessary to increase the size and weight of the floc particles, so that they can settle even in the presence of water currents that tend to keep them afloat. This "conditioning" is achieved

by flocculators or slow circular mixers, or, inefficiently, by the slow roll of the water at the entrance section of some basins without these devices. The presence of "old" floc is helpful in cold water, because it prevents supersaturation. A period of 15–45 min must be provided for floc growth (conditioning). Keeping the floc intact and the suspended matter entrapped is sometimes difficult. Unknown factors appear to produce a fragile precipitate, and any floc can be broken up by rough handling due to excessive flow velocities, falling over weirs, passage through partly closed valves, and the like. In most waters a floc, once broken, cannot be reconstituted.

Sedimentation

Sedimentation is a process of clarification achieved by channeling a coagulated water through a basin at velocities low enough to allow suspended, coagulated particles to settle out. The greatest enemy of efficient settling-basin operation is "short-circuiting"—the flow of a portion of the water on such a path as to bypass part of the basin and reduce the period of retention. Probably, few basins ever approach 100 per cent retention. It is surprising that more plants are not studied to eliminate such poor operation. The currents and directions of flow in a basin at various depths can readily be determined with easily prepared floats and markers and can then be corrected by baffles.

Filtration

In many plants, the role of filtration has been reduced through prechlorination to that of a final polishing process. A rapid sand filter, when operated properly, is a good polisher, but much remains to be learned about the filtrability of water. Many an operator has learned to his sorrow that, despite apparent clarity, low turbidity, and good settling, an applied water cannot necessarily be depended upon to insure long filter runs. Runs of 6–8 hr at times of high demand can make a filter installation the bottleneck that prevents a plant from keeping all of its consumers adequately supplied. When the cause of rapid clogging of the filters is an algal growth, the remedy may be found in the use of copper sulfate, either in the impounding area or (in higher dosages) at the entrance to the settling basins. The application of lime to the water going on the filters has often helped in a situation of this kind. This treatment apparently results in the production of a more porous or permeable floc that permits considerably longer filter runs between washings.

Clean filter sand is to be desired, and throwing the burden of dirt removal on the sedimentation basins appears a proper procedure. Mudball formation may still be a problem, but prechlorination, surface wash, and a better understanding of the importance of getting the proper sand expansion during washing will minimize the difficulty.

Conclusion

Obviously this short paper cannot do justice to the many problems of water treatment. It is hoped, however, that the complexities facing the average water works operator and the need for increased research in this field have been indicated.

Pumping—*Victor A. Appleyard*

A paper presented by Victor A. Appleyard, Chief of Water Operations, Water Dept., Philadelphia.

The subject of pumping is obviously too broad to be covered in the limited space available. Therefore, this paper will be confined to the type of pumping equipment most commonly used in water works—the centrifugal pump with an electric motor as prime mover. As its name indicates, this pump operates on the principle of centrifugal force. As the impeller spins, the water is sucked into the pump and flung away from the center of the impeller toward the edges. Because the pump case prevents the water from escaping, its pressure builds up. When it becomes great enough to overcome the pressure in the discharge piping, the check valve is pushed open and the water starts to flow into the line.

The performance of a centrifugal pump, generally expressed as a head-capacity curve, depends on its speed (revolutions per minute), the diameter of the impeller, and the size of the vane and pump case suction and discharge openings. The wire-to-water efficiency of the pump will vary with the capacity, as will the brake horsepower required. Pumps will continue to perform in accordance with their characteristic curves as long as their parts are maintained in good condition.

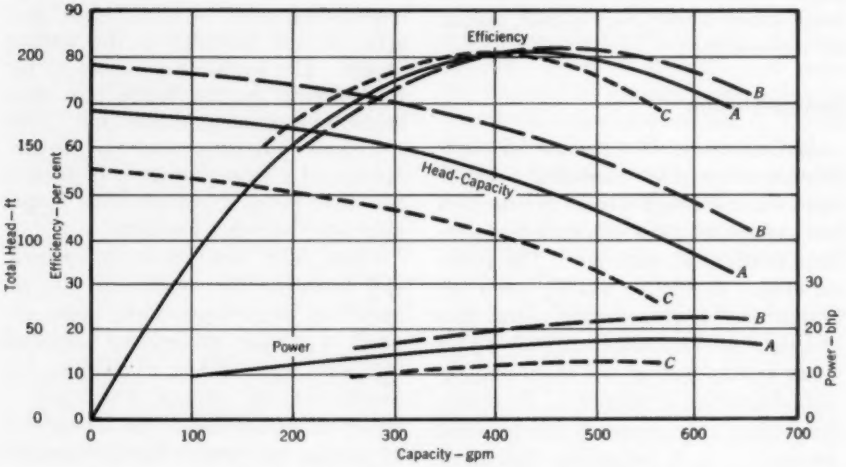

Fig. 1. Centrifugal-Pump Characteristic Curves

Key: A—*3,500-rpm speed, 7-in. diameter impeller;* B—*3,500 rpm and 7½ in., or 3,740 rpm and 7 in.;* C—*3,500 rpm and 6¾ in., or 3,130 rpm and 7 in.*

In Fig. 1, the solid lines (Curves *A*) apply to a pump designed to deliver 450 gpm at 130-ft total head in normal service. Under these conditions, the efficiency curve for the pump (Curve *A*) is about at its peak of 82

per cent, and the power required is approximately 16 bhp. Of course, the pump will not always be operating under design conditions. For example, in the early evening of a hot summer day, when the customers are all sprinkling their lawns, they use so much water that the head in the distribution system may drop 20 ft (8.7 psi). Against the resulting head of 110 ft, the pump, operating alone, will deliver water at a rate of 525 gpm. Thus, the power requirement will increase to 18 bhp, and the efficiency of the pump will be reduced to 79 per cent. As the 2-bhp increase is equivalent to a 12.5 per cent increase in rated load, a significant rise in motor temperature can be expected. During such periods the operator or engineer must be extremely alert, because the temperature of the motor may be approaching the point at which the thermal overload trip will shut it off. This situation can be remedied in two ways: another pump unit may be put on the line, thereby increasing the discharge pressure, or else the discharge valve on the first pump unit can be throttled. In either event, the head or pressure will be increased and the flow rate reduced, thus lowering the power requirement.

To take another example, if consumption of water is at a minimum, as in the early morning hours, the pressure builds up in the distribution system and the pump flow rate falls, necessitating less power. It is not unusual to start a pump with the discharge valve closed, so that the pump is at maximum or "shutoff" pressure. Under that condition, the flow is zero and the power requirement is at a minimum.

Curve *A* in Fig. 1 represents a pump with a speed of 3,500 rpm and an impeller diameter of 7 in. If either of these is increased, the head-capacity curve shifts upward (as in Curve *B*), indicating that the pump will deliver a greater flow than the Curve *A* pump at a given total head and will require more power. On the other hand, Curve *C*, for a pump with a lower speed or an impeller of smaller diameter, is displaced downward. The efficiency curves, too, change slightly, but usually the peak point remains the same as long as the speed or diameter variation is within 10 per cent. The relationships between flow rate (Q), speed (S), diameter (D), total head (H), and power (P) can be expressed by the ratios:

$$\frac{Q_1}{Q_2} = \frac{S_1}{S_2} = \frac{D_1}{D_2}$$

$$\frac{H_1}{H_2} = \frac{S_1^2}{S_2^2} = \frac{D_1^2}{D_2^2}$$

$$\frac{P_1}{P_2} = \frac{S_1^3}{S_2^3} = \frac{D_1^3}{D_2^3}$$

System Operation

The foregoing has dealt with a single pump unit in operation, but it is more usual to have at least two units pumping into the distribution system. Before discussing this situation, it is appropriate to consider briefly the "system head" curve, which characterizes the distribution system in terms of flow and total head. The total head in the system is the sum of the static and friction heads. The static head is the vertical distance through which the water is being lifted—for instance, from the level of the clear-water basin (from which the pumps take suction) to the

highest point in the system, perhaps an elevated tank. The friction head is measured by the pressure necessary to overcome the friction in the pipelines when water is flowing. The friction head increases with the flow rate, as is evident from the system head curve in Fig. 2. It will be noted that a vertical lift or static head of 120 ft (about 52 psi) must be overcome by the pump before water even starts flowing. To deliver a flow of, say, 900 gpm would, will deliver when on the line by itself. For greater flows, Pump No. 2 can be used alone, up to Point *Y*. The flow with both units operating can be found by adding the flow of No. 1 to that of No. 2 at the same head. This information has been plotted on the graph (broken curve). Point *Z*, where the combined head-capacity curve crosses the system head curve, indicates the maximum total flow that can be delivered by the two pumps together.

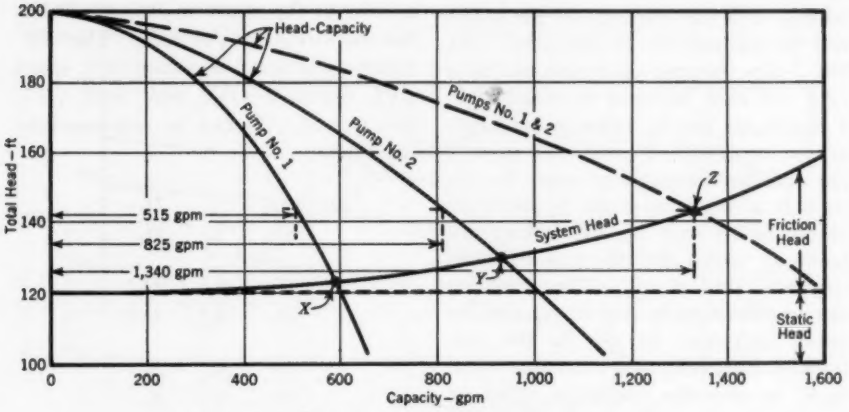

Fig. 2. System Head Curve With Pumps in Parallel

The points of intersection (X, Y, *and* Z) *indicate, respectively, the maximum flow using Pump No. 1, Pump No. 2, and both pumps together.*

according to the curve, require pumping against a head of almost 130 ft. It should be remembered that, as long as there are no changes in the distribution system, the system head curve will remain the same.

Figure 2 also shows the head-capacity curves of two pumps, No. 1 and 2, with rated capacities of 515 and 825 gpm, respectively, at 142-ft head. Point *X*, the intersection of the No. 1 curve and the system head curve, indicates the maximum flow that this unit

It is evident that the slope or steepness of the system head curve very much affects the output of the pumps. If the distribution pipe system is old and badly corroded, or if valves are stuck in closed position, the added friction will raise the total head and make the curve steeper. Consequently, the pump units will deliver less water and may be unable to attain their rated capacity.

It is possible to connect two pumps in series, the discharge of one being

piped to the suction of the other. For such installations, the pumps selected usually have identical head-capacity curves, and a single prime mover drives both at the same speed. At any given rate of flow, two pumps in series will develop a combined head equal to the sum of the two individual heads at that rate. On this basis, the two pumps can be treated as a unit in plotting a combined curve like that in Fig. 2.

Checklist

Pumping station personnel cannot do a great deal about such fixed conditions as distribution system friction or pump head-capacity curves, but they can and must make the station operate safely, dependably, and efficiently. The operator should:

1. Check the motor voltage and keep it at the rated value at all times.

2. Check the motor amperage often and compare it with the full load rating. Excessive loads overheat the motor and shorten its life. If a change occurs, the pump flow and pressures should be checked to see whether a change in pump load is the cause or whether something is wrong with the motor itself.

3. Examine the bearings, see that lubrication is proper, and make sure the temperature of both the motor and pump is not too high.

4. Be certain that the motor and pump are operating smoothly. Excessive vibration will cause rapid wear of bearings and other parts. A sudden change in vibration may indicate an obstruction in the pump, which might cause much damage.

5. Check the seals on the pump and make sure that water is both sealing as well as cooling the pump sleeves. If the packing is pulled up too hard, it will overheat, become hard, and then cut the brass sleeve. Tightening packing glands too greatly can add to the motor load, as the ammeter will show. The packing is there merely to hold the water seal at the sleeve and keep air from leaking into the suction of the pump. If air enters, the pump will not function properly, if at all. Again, a check of pressure, flow, and motor load will indicate whether or not the unit is performing as it should.

6. At least once an hour check the pump flow, suction and discharge pressures, and speed (if variable).

7. Keep a log of all these observations, so that a slow change in condition can be detected. Such gradual changes may be a symptom of trouble and should be investigated thoroughly.

Testing Program

These recommendations indicate the importance of instruments and gages in pump operations. There should be enough gages on a unit to show exactly how it is performing, and they must be checked for accuracy periodically. A regular program should be set up to test all instruments in the station approximately once a year.

It is suggested that a periodic test also be run on each pump unit. The test does not have to be as accurate as that for acceptance of a new unit, but it should permit a few points to be plotted on the original head-capacity curve. If these points fall close to the curve, the pump is in good condition—that is, the impeller, wearing rings, and the like are not badly deteriorated.

The increased power cost due to pump wear can be estimated by simple calculation: find the difference between the number of kilowatt-hours now required to deliver the normal flow

rate and the number required when the pump was new (this information can readily be obtained from the head-capacity curve); next multiply this difference by the average cost per kilowatt-hour and by the number of hours of operation per year. It will then be possible to tell whether it is more economical to spend a large amount of money on renovating the pump in question than to maintain it in its present mechanical condition.

To use as a reference when testing a pump unit, the author recommends the standards of the Hydraulic Institute, New York. These standards are accepted by the manufacturers and by many members of the water works industry.

Conclusion

An understanding of the basic principles briefly described in this paper is necessary for proper operation of centrifugal-pump installations. Because electric power for pumping is a large cost factor, top efficiency must be obtained from both men and equipment. The best assurance of reaching this goal is to have well informed personnel and a regular preventive maintenance program.

Distribution—*George F. Eynon*

A paper presented by George F. Eynon, Mgr., South Pittsburgh Water Co., Pittsburgh, Pa.

Because distribution facilities are largely underground, the public is not aware of the tremendous investment required to build them and is inclined to take them for granted. A study of a group of privately owned water companies revealed that, of a total investment of $217,500,000 in all classes of property, almost half—$107,500,000—was accounted for by distribution mains, services, meters, and hydrants. This high ratio illustrates the important part that these facilities play in water service and in the cost of providing it.

Construction and Installation

In view of current high prices and inflationary pressures, it is imperative to construct distribution facilities in such a manner as to secure many years of dependable service at the least possible cost consistent with good engineering and business practices. Some of the basic principles that should be adopted when installing water mains are set forth below:

1. Pipe should never be installed directly on rock. A dirt cushion at least 6 in. in depth should be provided between the rock and the pipe.

2. In backfilling, dirt free from rock should be deposited in layers and be well tamped under and around the pipe up to the spring line, to provide a firm and even bearing for the full length of the pipe. With today's extensive use of mechanical equipment, this point is often overlooked, especially where pipe is installed by forces other than those of the water utility. A void under the pipe subjects it to damage from the weight of the backfill and traffic over the trench.

3. Pipe should never be installed in filled ground unless the fill has been thoroughly compacted to prevent settlement.

4. Thrust blocks should be installed wherever changes in the size or direction of the pipe occur—at bends and tees, for example. Spacers should be inserted in sleeves near reducers or valves to prevent joint separation under pressure.

5. When extending threaded cast-iron pipe from an existing main of the same kind, the length at the beginning of the extension should have a mechanical joint in order to permit alignment of the newly installed pipe with the trench without placing a strain on the threaded joint.

6. Cinders or other corrosive materials should not be allowed to come in contact with pipe. For that reason, it is often necessary to use extreme care in backfilling.

When the installation of mains is being planned, it is well to confer with representatives of other utilities and with municipal and state highway department officials to determine the location of subsurface structures and established street grades, thus avoiding costly delays and changes during construction. At the same time it should be determined, so far as can be done, whether street or road construction involving changes in grade and location is planned. It may thus be possible to avoid the expensive procedure of relocating or lowering water mains at a later date in order to permit the installation of sewers, culverts, and the like on a fixed line and grade.

The installation of valves at locations that will permit shutting down sections of the system with minimum interruption of local service and minimum interference with the general operation of the system is most important. All fire hydrant branches and all branches from principal feeder mains should be valved. In general, it is good policy to locate valves systematically at street or property lines, so that they can be more easily found when needed. This procedure, however, is not always possible when connections for branch lines are made with a tapping sleeve and valve unless an additional valve is installed at the property line.

Provision should be made for dewatering pipelines by placing blowoffs at the low points along the main. Likewise, air valves should be installed at the high points as a means of venting air from a main after a shutdown. This practice is especially desirable in the larger pipelines or feeder mains from the source of supply. Frequently fire hydrants, if suitably located, can be utilized to dewater and vent pipelines.

Curb or service boxes installed in roads with no curb should be situated far enough from the edge to be out of range of graders and snow plows. This may require the installation of a few additional feet of service pipe initially but can result in considerable savings in time and maintenance expense.

Many water works operate in localities where streams are polluted with acid mine drainage. When a metallic-pipe crossing is installed in such a stream, the line should be encased in concrete to protect it from the corrosive effects of the polluted water.

The big part which labor costs play in expenditures cannot be overlooked. Labor rates are now three or four times what they were 15 years ago, and workmen are usually paid on a portal-to-portal basis. To achieve more efficient use of manpower, foremen and other supervisory employees must plan their work wisely, and well in advance of the time it is to be performed.

Maintenance and Repair

Even the best constructed water distribution systems require maintenance, generally of a kind that cannot be scheduled. Breaks and leaks appear to have a habit of occurring at the most inconvenient times and under the most adverse conditions. Nevertheless, the utility must be prepared to make repairs and restore service in the shortest possible time, in order to minimize inconvenience and property damage. Personnel must be organized and trained to respond to calls immediately, and a workable method of reaching the employees required and getting them to the scene of the trouble is most important. A stock of parts sufficient to make repairs on any size of main in the system should be maintained. In addition to the usual small hand tools, the following items should be available to, and preferably owned by, all water utilities: transportation equipment; an air compressor and pneumatic tools; trench pumps; portable lighting equipment; and barricades, danger signs, and red lanterns.

If the purchase of an air compressor would impose too great a financial burden on a small water utility, the foreman should have access to such equipment from more than one source at any time. Even some of the larger water utilities do not own heavy construction equipment like cranes, backhoes, or bulldozers, but persons in charge should know how and where to hire them on short notice when necessary.

In a serious main break, it is not always possible or practical to notify all consumers who will be affected by a shutoff. Every effort should be made, however, to notify those having expensive machinery and equipment that might be damaged by an interruption of service. Whenever possible, all consumers affected should be notified in advance of a shutdown.

Frequently a water main break will undermine the pavement in a wide area surrounding it. The extent of the undermining should be ascertained and the affected area barricaded or roped off to protect the public. It is often necessary to enlist the help of police to divert or direct traffic around the area.

When a main is being installed or repaired, all possible sanitary precautions should be taken. The main should be thoroughly flushed and disinfected with chlorine compounds before it is restored to service.

Every water system should be equipped with certain tools and instruments that are necessary to its efficient operation. Some of the more essential items are pressure gages, aquaphones, pipe locators, magnetic dip needles, and geophones or other leak locators. It is also necessary that those who use these instruments be properly trained, despite the relative simplicity of many of the devices. One of the most important and useful tools in the operation of any water system is the pressure gage, yet the abuse to which this delicate instrument is often subjected is amazing. A pressure gage, if properly used and cared for, can furnish valuable information to the water works operator. On the other hand, inaccurate gages will produce misleading data. It is, therefore, important that gages be kept where they are not exposed to jarring or to great temperature changes. They should be checked frequently with a dead-weight tester.

Pressure and Flow Data

Although much of the data obtained from instruments must be interpreted

or evaluated by experienced engineers to be useful, all water works operators should be familiar with the fundamentals of hydraulics. Water pressure, in itself, means little as an indication of how the system is performing, so long as all consumers in the area are receiving water. In forecasting pressures or designing improvements, it frequently becomes necessary to make a survey to determine the hydraulic gradient, by means of which all points in a system, regardless of ground elevation, may be related to each other and to a common point.

The hydraulic gradient, an imaginary line drawn between two or more points, is determined by adding the pressure in feet (2.31 times pounds per square inch) to the gage elevation of the points selected. For example, the gradient value at a hydrant at el 900.00 having a pressure of 30 psi would be $900.00 + 30 \times 2.31 = 969.30$. If, at a hydrant 1,000 ft distant, the hydraulic-gradient value is 962.10, the pressure or head loss due to friction in the pipeline between the hydrants is 7.20 ft. As one goes away from the source of supply, the hydraulic gradient becomes lower, and, for a given quantity of water flowing, the smaller the pipeline, the more rapidly the hydraulic gradient falls. The hydraulic gradient across a distribution system is obtained by taking simultaneous pressure readings at several points along the route selected. Readings are taken at intervals of 1,000 or 2,000 ft and at all major pipeline intersections. After the gradient values have been computed in the manner described, they are plotted on graph paper in proper scale and connected by straight lines. The slope of the gradient is then readily apparent.

Sharp or sudden drops in the hydraulic gradient indicate high rates of flow or reduced main capacity. If excessive drops occur without apparent good reason, it is suggested that an investigation be made for leaks, closed valves, or obstructions in the pipeline. The source of the difficulty can be localized or pinpointed by determining additional gradient values at successively smaller intervals. Hydraulic-gradient tests should be run at a time of day when the load is almost constant and, in order to determine weaknesses in the distribution system, at times of peak consumption.

Reference was made earlier to head loss due to friction in a pipeline. The amount of friction that occurs in a pipe varies with the speed with which water flows through it and with the roughness of the pipe interior. The roughness coefficient or C value is a measure of the resistance that a pipe offers to the flow of water and is thus an indication of the condition of the interior surface. By measuring the hydraulic gradient at two points in a pipeline of known size, the distance between the points, and the quantity of water flowing between them, the C value of the pipe can be computed from the Hazen-Williams formula or determined from tables or loss-of-head curves available in most water plants. The latter method is suggested for all except experienced engineers or mathematicians. It yields results that are sufficiently accurate to enable water works operators to solve many of the more common operation problems. When, however, hydraulic studies are to be used for designing improvements that will involve the expenditure of large sums of money, it is recommended that the analyses be made or supervised by a qualified engineer familiar with such work.

Probably the most common device for measuring flow in a pipeline is the

pitometer. This instrument, inserted in the line through a corporation stop, measures the velocity of the water by means of pressure differentials. Instructions for the use of such an instrument are available from the manufacturer and, if followed, will produce accurate results.

One of the most common checks on water works distribution systems is the hydrant flow test. A pressure gage is installed on one nozzle of a hydrant and the pressure observed while water is flowing through another nozzle of the same hydrant. The pressure can also be obtained by means of a pitot gage held in the center of the flowing stream, but it is believed that there is less chance for error if the former method is used. When the pressure is known it is a simple matter to find the flow rate from the formula, $Q = 27d^2\sqrt{P}$, in which Q is the flow rate (gpm), d is the inside diameter of the flowing nozzle (in.), and P is the pressure (psi).

Other Items

Complete, accurate, and up-to-date records are invaluable in the operation of a water works system. A map of the system showing all mains, hydrants, valves, and storage reservoirs or tanks should be made and kept current. A record of each hydrant and valve in the system should be maintained, including the location, date of installation, size, make, direction of opening, and other pertinent data. The location of valves should be indicated by measurements from fixed points, so that they can be readily found when needed. (Even valve boxes in paved streets may be hidden by several inches of snow, ice, or water.) Each service should be numbered, and information on the location of curb and corporation stops, size and kind of pipe, date of installation, and historical data should be kept on file.

The original records of older water systems are often lost or destroyed. With a little effort, however, much data on mains and other facilities can be accumulated when repairing breaks and leaks, installing services, and making connections to the system for extensions. If valve records are not reasonably accurate and complete, it is suggested that a survey be undertaken to find and record the location of the larger and more strategically located valves. Valves and hydrants should be inspected at periodic intervals and a record kept of the work performed.

A record should be made of all repairs of main breaks and leaks, showing the time of notification of the trouble, by whom reported, the time of shutoff, the location of the valves operated, the size and location of the main, a description of the nature of the leak, the time of completion of repairs and restoration of service, and any other pertinent data.

The distribution system should be thoroughly flushed once or twice a year. This should be done systematically, starting at the source of supply and working toward the extremities of the system, using hydrants and blowoffs for the purpose.

Unaccounted-for water is a matter of concern, especially if the supply is limited and has to be treated and pumped. The leaks that are apparent on the surface always receive attention, but much water is lost through underground leakage to sewers, rock crevices, and abandoned mine workings. Very often such leaks remain undetected for long periods, so that the water lost represents a considerable amount of money

wasted. Another result may be the imposition of otherwise unnecessary restrictions on the use of water in order to conserve a limited supply. Hidden leaks can also cause needless expense by undermining streets, sewers, buildings, or other structures and inviting costly damage claims.

Any abnormal increase in pumpage should be investigated immediately if the cause is not known. Periodic surveys, using a geophone or aquaphone to sound hydrants, valves, and curb stops, will frequently reveal hidden leakage. Alert meter readers and other employees should report suspicious conditions. Inspection of sewer manholes and streams in dry weather often produces evidence of leakage, which should be tracked down.

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Reprints of the following articles, published in the JOURNAL during the preceding year, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 521 Fifth Avenue, New York 17, N.Y. Prepayment is required from nonmembers. (Note: This list does not include specifications and similar documents kept permanently in stock.)

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Distribution System Maintenance in Cold Weather

Joint Discussion

A joint discussion presented on Sep. 4, 1953, at the Minnesota Section Meeting, Winnipeg, Man.

Care and Maintenance of Hydrants—*H. H. Behlmer*

A paper presented by H. H. Behlmer, Supt., Water Dept., Fargo, N.D.

THE location and proper installation of fire hydrants play a very important part in the program of care and maintenance during the winter months, when temperatures may fall to as low as −30° or −40°F. Hydrants should be placed at least 6 ft from the curb in a residential area, to prevent them from being damaged or covered with snow by snow removal equipment operating close to the curb. At street intersections, it is advisable to install hydrants well away from the corner, to protect them against skidding vehicles. In congested districts, where the walks extend from the building line to the curb, the width of the walk must be kept clear of obstructions and the hydrants located as near the curb as possible. As the usual procedure in such areas is to remove the snow from the streets and not push it back over the curb, the hydrants are not endangered. All hydrants should be set so that the pumper nozzle will be at least 18 in. above the walk or ground, and the hose nozzles at least 24 in. in the clear. The higher the hydrants above grade, the less the danger of their being covered by snow ridges or drifts.

Hydrants installed in impermeable ground must be provided with some means of artificial drainage. Usually ½–¾ cu yd of crushed rock, placed around the base of the hydrant before the trench is backfilled, will provide a drainage area equal to the capacity of the hydrant barrel. The finished grade around the hydrant should be a little higher than that of the surrounding area, to prevent surface water from collecting during thaws. Every hydrant should have a gate valve on the lead from the main, so that the water can be turned off while repairs are being made.

At Fargo, N.D., the equipment for checking hydrants for poor drainage consists of a 10-ft length of light chain with a loop handle at one end and a small lead weight at the other. The pumper nozzle of the hydrant to be checked is removed, and the weighted end of the chain is lowered until it hits the bottom of the hydrant or meets an obstruction. Any water or ice in the barrel is easily detected. The hydrant is also checked for proper closure. The noise of a leaking valve can usually be detected by ear or by any instrument that will magnify the sound. Faulty valves are replaced as soon as possible. The men making the routine hydrant inspections soon learn which

hydrants are likely to give trouble. Any hydrant used by the fire, street, or park department is reported to the water department, which checks it for proper drainage.

Hydrants in areas where the ground water is high enough to enter through the drain holes must be specially protected from freezing. If the drains are kept permanently plugged, the hydrant must be pumped out after each use. Several brands of antifreeze are suitable for hydrant protection. Salt solutions should never be employed, owing to their corrosive action on the operating mechanism and the hydrant barrel. The antifreeze must be replaced every time the hydrant is used.

Fargo makes its own hydrant pumps from a section of brass tubing threaded at both ends. The plunger consists of a cup leather and washers attached to a brass rod that extends through the top of the cylinder and is fitted with a handle. A check valve and a length of noncollapsing hose, sufficient to reach to the bottom of any hydrant, are attached to the base of the pump by a short section of pipe, which also acts as a footpiece for the pump. A spout at the top of the pump releases the water. The apparatus operates like a tire pump in reverse.

A hydrant which, in spite of the greatest vigilance, has become frozen must be thawed out as soon as it is discovered. For this purpose, Fargo employs a portable oil-fired steam boiler that can easily be placed in the back of a pickup truck. The boiler holds 5 gal of water and will develop a head of steam in 60 sec. An attached hose, lowered through one of the hydrant nozzles, conducts the steam to the ice, which is soon melted and can be pumped out.

In areas where hydrants are subject to burial by drifting snow, a small metal flag atop a vertical rod of any desired length can be placed on the hydrant to show its location. Such markers can be purchased from water works supply houses. The assistance of the local residents may also be requested. For example, a notice like the following might be published in a newspaper: "The fire hydrant nearest you may be urgently needed to put out a fire in *your home*. Help us to help you by keeping the hydrant clear of snow."

The water department has experimented with many types of oil and grease to lubricate the threads of the steamer and hose nozzle caps, in order to keep them from sticking in cold weather. The best lubricant found to date is a 1 : 1 mixture of SAE 10 motor oil and a light, reinforced lubrication oil.* The nozzle caps are easily removable in the coldest weather, as this mixture will not congeal or absorb moisture.

* A product (below SAE 6) of the Marvel Mystery Oil Co., New York, is used.

Thawing of Frozen Pipes—*Paul Buccowich Jr.*

A paper presented by Paul Buccowich Jr., Supt., Light & Water Dept., Ely, Minn.

The freezing of water pipes is a constant source of annoyance, both to utilities and to consumers. The quickest and most efficient thawing method is the direct application of heat to the pipe at the point where it is frozen. This can be done by passing a heavy current of electricity through the frozen section of pipe at a low voltage. Heat is developed in the pipe owing to the

resistance of the metal to the electric current. The heat is thus applied directly to the frozen part, and a minimum length of time is consumed in thawing out the pipe. (Copper pipe requires at least three times as long to thaw as iron pipe.)

Because of the many different conditions met in service, it is impossible to prescribe the exact voltage or current necessary. These quantities vary with the size, length, location, and properties of the pipe, as well as with the temperature of the outside air. Large pipes require less voltage than small ones to force the same current through a given length, but more current to heat the same length. For pipes up to 5 in. in diameter, approximately 500 amp is usually sufficient, while a 12-in. main may require 1,000 amp. For small pipes, a much lower current will be sufficient. As a rule, a small current for a long period will do the same work as a large current for a short period, with less danger of injury to the piping system.

For heavy service, the Ely, Minn., water department uses an outfit consisting of a choke coil and standard transformer, with carefully insulated parts and simple connections to insure that the operator incurs no danger. The transformer is brought as near to the portion of the pipe to be thawed as conditions will permit. The high-tension leads are connected directly to the transformer primary, and the low-tension leads are connected to opposite ends of the section of pipe to be thawed. In thawing residential service piping, one lead can be connected to a point below the water meter and the other to a convenient hydrant. For thawing street mains, two hydrants can be used. Great care should be exercised in making connections to the piping system; otherwise, pipe and hydrants may be burned and disfigured, owing to the heavy current going through poor connections.

The choke coil, which was specially designed to be connected (in series) with the primary of a 2,400-v, 60-cycle, 30-kva transformer, is mounted in a cast-iron case provided with suitable carrying lugs. The leads are connected to the choke coil through the handles of two contact plugs which fit the five plug sockets arranged to allow current adjustment. The secondary voltage can be decreased to approximately 95, 87, 75, 65, and 50 per cent of the normal voltage by the insertion of the contact plugs in the proper sockets. The leads and handles of these plugs are insulated with a material capable of successfully resisting much greater potentials than will ever be encountered in actual service. It is impossible to injure the transformer or choke coil by making a wrong connection.

The transformer, choke coil, and two mounted wire reels, with extended spokes, are on a four-wheel trailer. The primary wire is No. 12 (3,000-v insulated) and the secondary is bare copper wire, either No. 2 (for service pipe) or No. 4 (for mains). The wire from one reel is connected to the hydrant and the wire from the other reel to the service. The connections from the transformer to the bare wire are made with hot-line tap clamps. The reels are insulated from each other.

This apparatus has proved quite satisfactory. No failures have yet been encountered in its use.

Hydrant and Valve Maintenance in Small Plants

By Francis H. Connors

A paper presented on Sep. 10, 1953, at the Ohio Section Meeting, Cleveland, Ohio, by Francis H. Connors, City Engr., Van Wert, Ohio.

THIS paper is not intended to be a technical discussion of the installation and maintenance of valves and hydrants. Its object is rather to set forth what may seem to be some very obvious facts regarding these appurtenances along with some general recommendations on their installation and maintenance in small water works. Unfortunately, some of the facts herein presented are so obvious that there is a tendency to overlook them.

It should be recognized that small water systems have problems of operation and maintenance that are peculiarly their own and that are, in many instances, not faced by larger plants. First, there is the matter of personnel. General responsibility for the operation and maintenance of the water plant and the distribution system frequently rests on an individual who, whatever his title, often has numerous duties other than those connected with the water works. In many small villages, the water superintendent reads meters, runs the plant, makes repairs, acts as the town marshal, and holds down a job elsewhere to make a living. Water works employees, having to be jacks-of-all-trades, sometimes fail to become masters of any.

Then there is the matter of costs. It is, of course, not implied that the larger cities have no cost problems. Certain aspects of the cost situation are, however, accentuated in the small system. Numerous small systems operate on a financial shoestring. Many can operate only by "deferring" (a polite term for neglecting) all, or practically all, maintenance. Revenues are sufficient only for bare operating necessities. Furthermore, additions or betterments to the system or additional personnel are, quite frequently, proportionately greater burdens to the smaller system than to the larger. Adding a man or two to the small plant's payroll often means increasing it 25, 50, or 100 per cent. Interest rates on bonds sold for improvements are frequently substantially higher for the smaller systems. Indebtedness is, in many instances, a greater strain on the revenues of small systems than on those of larger ones. These and similar problems must be kept in mind when discussing hydrant and valve installation and maintenance or other aspects of small-plant operation.

Records

The proper maintenance and, to a somewhat lesser extent, the proper installation of valves and hydrants are not possible without records that are adequate, though not necessarily elabo-

rate or complete. Not all types of records are essential or even desirable for all systems. Small systems require simpler records than do larger ones.

In order to establish a system of records, the form and extent of the records to be maintained should be determined and a method should be devised to make sure that they are kept up to date. The records should be as simple as is permitted by their intended use, and the method of keeping them current should be followed consistently, without fail. A simple record, accurate and up to date, is better than an elaborate system established at great effort and then allowed to wither on the vine. Content, not form, is the essential element in a system of records.

For the smaller water works, a system map and valve records are generally sufficient. In very small utilities, the system map alone can sometimes be made to provide all of the necessary information. (Some data on service installations and meter settings will also be required for operation and accounting purposes.)

The system map, as the name implies, is a map of the entire system on as large a scale as practicable—usually between 400 and 1,000 ft to the inch—showing all mains, main sizes, valves, hydrants, street names, reservoirs, elevated tanks, supply sources, and any other useful information that can be included in the space available. If the scale is small, street lines are preferably omitted. A print of the system map should be mounted where it is readily accessible to all persons concerned with the operation of the system. If desired, several prints may be divided into convenient sections and bound for easier use in the field.

Valve records may take the form of "intersection plats," with each street intersection represented by a separate drawing on which is shown all the information pertinent to the valves at that location. A simpler system is the "valve plat and list." For the small water works, this record can be compiled by cutting prints of the system map into sizes convenient for carrying in a loose-leaf binder. Each valve on the map is numbered and is listed on a sheet in the same binder, together with all pertinent information on its location and operation.

In some of the very small systems, records are practically nonexistent. In certain states, a good start toward establishing a record system can be made by using the system map contained in the most recent inspection report filed by a state agency. With this as a basis, if all new information is noted as it becomes available, a fairly adequate record can be compiled in a relatively short time.

One excellent source of information is a written record of all excavations and repairs in the system. The author has found that merely recording such items as size of main, depth of cover, and distance from curb line whenever a new tap or repair is made will soon result in a surprising amount of data and in the correction of errors in existing records. For this purpose, it is well to provide each crew with a sturdy notebook and insist that an entry be recorded every time an excavation is made. Reporting such items as difficulties in making shutoffs during repairs will sometimes give a clue to the location of a lost valve.

Importance of Valves and Hydrants

The negligence too often apparent in the installation and maintenance of

valves and hydrants stems from two causes: First and fundamentally, their importance, although it may be admitted in theory, is often ignored in practice. Second, the fact that all mechanical devices are subject to failure tends to be forgotten, especially when they are buried under several feet of earth. "Out of sight, out of mind" aptly describes the situation.

The fire protection function represents a large percentage of the initial cost of every water works and a sizable proportion of its operational cost. All of this investment is wasted if hydrants do not function properly when called upon to do so. That they were in good condition a month or a year before a disaster occurs is small consolation to those whose life or property is lost because they would not perform in time of need.

The primary function of valves is to control the flow of water in a distribution system. Such control is necessary to facilitate repairs and minimize the inconvenience and danger to consumers in the event of breaks or other emergencies. Like hydrants, valves are useless if they will not operate in emergencies. The importance of both valves and hydrants, and the need for proper installation and maintenance, are evident.

Installation

The installation of valves and hydrants is so thoroughly covered in the literature and in manufacturers' handbooks that only a few aspects will be touched on here. The spacing of hydrants is generally fixed by the requirements and recommendations of the National Board of Fire Underwriters (*1*), state inspection bureaus, and similar agencies. The exact location of an individual hydrant should be made with an eye to the future, taking into consideration such diverse factors as possible street widening or grade changes, new driveways, the habits of truck drivers, and the growth of trees. Valves should be installed on all hydrant branches. The relatively high initial cost is repaid in easier repair and maintenance and consequent higher efficiency in the hydrant installation. The use of the breakoff type of hydrant should be considered.

The reliability of a system depends greatly upon the number and location of its valves. The National Board of Fire Underwriters (*1*) recommends that valves in the distribution grid should be installed so that not more than 500 ft of main in the high-value districts nor more than 800 ft in the residential areas would have to be shut down because of any single break. In this connection, it is well to remember that water is finding increased use in homes for such purposes as air conditioning and garbage disposal. Outages due to breaks cause correspondingly greater inconvenience to the consumer. The extent of such outages must, therefore, be limited, as far as is economically possible, through the installation of sufficient valves.

Important valves located in well paved streets with heavy traffic are best installed in manholes for ease of inspection and maintenance. One excavation and pavement replacement, in a situation of this kind generally will, if all expenses are considered, nearly equal the initial cost of a manhole. In the author's opinion, cone valves, with their inherent rapidity and ease of operation, even against unbalanced pressures, should find more use, particularly in the larger sizes, than they now do. Additional valves may be quite easily installed in the system by

using cutting-in valves or valve-inserting machines.

Maintenance

Distribution system valves, unlike most other mechanical devices, seldom wear out because of excessive use. On the contrary, they become inoperative owing to disuse. To insure, as nearly as possible, that they will function when needed, they should be operated periodically—at least once a year.

The smaller systems have neither the personnel nor the finances to support a regular inspection and repair crew. Consequently, this responsibility must rest on the regular personnel. Herein lies one of the greatest enemies of an adequate program. An inspection and maintenance program cannot be properly carried on if it is regarded as an added duty to be attended to in spare time during the year. Enough spare time does not seem to occur in the operation of most systems. Consequently, the program should be recognized as a primary duty, a definite period allotted to it, and all available personnel concentrated on it during that time. It should take precedence over routine operations, so that the foreman or superintendent, with other matters temporarily neglected, will have time to see that it is done correctly.

The inspection itself should consist of operating every valve on the system, using the valve records and a simple check list to insure that none is missed. Minor repairs, such as replacing broken valve box covers and cleaning out the boxes, can be made during the inspection period. Major repairs should be listed and taken care of in due course after the inspection has been completed.

Probably the best time for this annual inspection is in the early fall. The hydrants can thus be checked before the onset of cold weather and after street maintenance and construction crews have done most of their damage for the year. Street maintenance crews rank high on the list of the natural foes that a water system must combat. They are especially efficient at hiding valve covers and breaking boxes. In their defense, however, it must be said that such pranks are their only means of retaliation against a water department that seems to spend most of its time digging holes in newly maintained or constructed streets. A little forbearance on both sides is indicated. If the valve records are adequate, covered valves will be located during the annual inspection, and necessary repairs can be made in less time, and with the expenditure of less energy, than is sometimes spent in loud recrimination.

What has been said about the maintenance of valves applies in large measure to the maintenance of hydrants. The annual hydrant inspection can best be carried out in conjunction with the valve inspection and can include routine lubrication, drainage, and minor repairs. Major repairs required can be noted and placed on the work schedule.

With the annual inspection completed in the early fall, a period of good weather remains, during which the required repairs—in the order of their importance—can be effected. It will thus be insured that the system will be in the best possible operating condition for the heavy strains imposed on it during the winter.

Reference

1. *Standard Schedule for Grading Cities and Towns of the United States.* Natl. Board of Fire Underwriters, New York (1942); *Jour. AWWA*, **34**: *following p.* 1584 (Oct. 1942).

Control of Corrosion in Underground Pipelines

By Hugh L. Hamilton

A paper presented on Jun. 23, 1954, at the Pennsylvania Section Meeting, Allentown, Pa., by Hugh L. Hamilton, Pres., A. V. Smith Eng. Co., Narberth, Pa.

THE corrosion of underground metallic pipelines is of major concern to the water industry. Corrosion can, and does, cause rapid depreciation of underground plant, as well as loss of water before it reaches the consumer's meter. Corrosion also shortens the useful life of some process equipment. The monetary value of such losses usually makes it economical to adopt measures for corrosion control.

Causes of Corrosion

Underground corrosion may be due to one or a combination of influences, including: stray direct current, corrosive soil, nonuniform composition of structural materials, and anaerobic sulfate-reducing bacteria. The mechanism of each of these is described below.

Stray Direct Current

Stray current is found flowing in the earth as the result of the operation of both intentionally and unintentionally grounded d-c systems. The most common offenders are street railways and electric railroads. Frequently difficulties are also caused by manufacturing plants and other d-c power users.

The operation of a d-c traction system illustrates the basic principles involved. The power for such a system originates in a substation, from which the current flows through an insulated overhead wire or third rail. The current is conducted to the traction car motor by a sliding contactor, flows through the motor, and then passes to the rails through the car wheels. The rails conduct most of the current directly back to the substation, but, as the rails are in contact with the ground, a portion of the current travels at least part of the way back to the substation through the earth. During this journey an underground pipeline may be encountered, which, if electrically conductive, may provide an electrical "shortcut" for the stray current. In that event, it will enter the pipeline and travel along it until a more desirable path to the substation presents itself. At the point where the current leaves the pipe and returns to the earth, it will take a portion of the pipe metal with it. The weight of pipe lost in this manner will vary with the amount of current and the chemical composition of the pipe. A steel pipe will lose 20 lb per ampere-year, a copper pipe 46 lb.

Several courses of action are available to control this type of corrosion:

1. The application of an electrically resistant coating to the pipe, to lessen the flow of current entering it.

2. The establishment of insulating sections in the pipe, to reduce the cur-

rent flowing along the pipe by eliminating the electrical shortcut.

3. The provision of a metallic path to allow the current that has entered the pipe to flow back to the substation without returning to the earth and taking pipe with it. When properly engineered, this method permits the structure to pick up current throughout the problem area, thus eliminating metal loss.

Any or all of these methods may be utilized in practice, depending on the particular circumstances.

Soil Corrosion

All soils commonly encountered are naturally corrosive. Some are so corrosive as to cause rapid deterioration of underground metallic structures. Others are only mildly corrosive and do not constitute an economic problem. One commonly encountered type of soil corrosion occurs when a metal pipe is laid partly in one kind of soil and partly in another. A lump of clay against a pipe in sandy soil is an example. The electrical properties of the metal are different in each environment, and, as a result, a current flow is generated. Where this current leaves the pipe, flowing to earth, corrosion occurs. The same ratio of metal loss to current flow exists as in stray-current corrosion.

Soil corrosion control measures, which can be employed singly or in combination, include:

1. The application of a coating barrier between environment and pipe. This prevents corrosion except at coating voids, which are practically inevitable.

2. The use of cathodic protection—the application of current flow from an anode, through the earth or environment, to the structure to be protected. When this current, which flows in the opposite direction from the current causing corrosion, is equal to or greater than the latter, corrosion ceases.

3. Selective backfilling. When known corrosive soils are encountered during construction, backfilling with a uniform soil that is less corrosive will extend the life of the main. Sand is often used for this purpose, but sand saturated with salt water is unsuitable.

Nonuniform Composition of Structure

If a structure is composed of two or more metals, accelerated corrosion of one or more of them may take place. This type of corrosion is very common. For example, when a copper service pipe is tapped to a cast-iron main, current flows from the latter to the earth and then to the copper pipe. The current completes its path by flowing along the copper pipe back to the cast-iron main. As corrosion occurs where current flows from a structure to the earth, corrosion of the cast-iron main results.

Galvanized pipe makes use of the principle underlying this type of corrosion. When a break occurs in the zinc coating of a galvanized pipe, the iron surface beneath the zinc comes in contact with the earth. Current then flows from the surrounding zinc coating to the earth and then to the bared iron surface. This process causes corrosion of the zinc coating but provides a measure of protection for the iron surface. Of course, as the zinc is consumed in protecting the bared iron surface, additional iron areas are exposed to the earth. Eventually, if the soil is sufficiently corrosive, not enough zinc remains to protect the uncoated portions of the pipe. From then on, corrosion continues until the pipe fails.

This type of corrosion can be controlled by one or more of the following methods:

1. The application of a protective coating. This tends to lessen the total current flow between metals but may result in a concentrated loss of current at a coating fault, leading to a rapid penetration.

2. The electrical insulation of different metals from one another. This will greatly reduce current flow and extend the life of the structure.

3. The use of cathodic protection. If applied so that all metals in the structure are receiving sufficient current from the earth, this method can decrease corrosion to a negligible quantity.

Sulfate-reducing Bacteria

Anaerobic sulfate-reducing bacteria are often active in stagnant water, densely packed clays, and other oxygen-deficient environments where woody substances are present. When these bacteria exist on the surface of a steel or iron pipe, their life process is such that corrosion of the metal results.

Methods for the control of this type of corrosion include the application of coatings and cathodic protection, often in combination. If the entire pipe surface is covered, the coating provides a physical barrier against the bacteria. The conditions produced by cathodic protection cause bacteriostasis.

Practical Applications

In order to control corrosion effectively, it is necessary first to determine the nature of the corrosion mechanism and then to design an economical system to counteract it. A few illustrative problems and solutions will be given.

Stray Traction Current

Two parallel steel mains crossed under the rails of a direct-current traction system. Near the point of intersection, a 2-in. service to a factory was tapped off one of the mains. This service paralleled the traction rails for about 300 ft before terminating. A substation of the traction system was located about 1,000 ft from the end of the service. The service failed shortly after installation, and extensive, deep pitting was also noted on the mains near the rail crossing.

An engineering survey made subsequent to the replacement of the service showed that stray traction currents were discharging to ground at the corroded areas when the nearby substation was in operation. This finding led to the design of a corrosion mitigation system —consisting of copper cables, current-limiting resistors, and an automatic switch—connected between the two mains and the rails of the traction system. The switch closes when the substation is operating, thus making it possible for the cables to conduct the stray traction currents from the mains to the traction rails and eliminating the previous loss to earth. When the substation is shut down, the switch opens, preventing the flow of current from the rails to the mains.

The entire cost of this system was $1,800, including both installation and engineering expenses. The operating cost is approximately $300 per year, covering maintenance and periodic engineering checks. Approximately 4 miles of 12-in. main and 50 services, with an estimated replacement value of $315,000, are protected by the system.

Soil Corrosion

A distribution system in a suburban town near a large metropolitan area was suffering leaks with increasing frequency. The area had previously been affected by stray traction currents. All traction systems operating on d-c cur-

rent, however, had been abandoned for about 5 years. Various types of coating had been applied to the mains when installed, except for a small section.

All available data on leaks were collected and their locations and frequency were plotted on a map. The soils in the area were surveyed and their relative corrosiveness was determined and tabulated. Tests were also made to learn the minimum cathodic-protection currents needed to protect various sections of main. Then a cathodic-protection system, comprising 49 magnesium anodes, was installed at locations indicated by the survey throughout the distribution network. When connected to the pipe the magnesium anodes corrode and the currents causing this corrosion flow through the earth to the steel mains. These currents counteract the corrosion currents on the mains, thus cathodically protecting them.

The engineering and installation of this system cost $1,000. It protects about 24,000 ft of main and 475 services, valued at $150,000. The cost of the protection system was kept down by the preliminary survey to determine the proper location for the magnesium anodes.

Bacteriological Corrosion

A portion of a high-pressure distribution system, parallel to and within a block of the ocean, was in a stratum of densely packed clay. The leak problem in this area was becoming increasingly troublesome, and the replacement of large lengths of main and numerous services seemed imminent.

A field survey of the area revealed that anaerobic sulfate-reducing bacteria were responsible for most of the corrosion experienced. The electrical properties of the soil in the immediate vicinity of the mains were found to be unfavorable for the use of magnesium anodes. Investigation determined that, if the anodes were buried in the ocean, the electrical properties of the salt water would result in the delivery of sufficient current to supply cathodic protection. Groups of magnesium anodes were therefore installed in the ocean at the foot of each street and connected by a copper cable to each main. The cost of protection was approximately $250 per street, each of which contained 800 ft of 2-in. main and 30 services, with a replacement cost of approximately $10,000.

Conclusion

By the application of sound engineering principles, it is possible to design economical corrosion control systems. Each of the protective systems designed resulted in considerable savings and greatly extended the useful life of the property involved. In every instance, the design of the control system was based on an analysis of the particular problem to be solved.

Status of Public Water Supplies in Kentucky

By Nick G. Johnson

A paper presented on Sep. 22, 1953, at the Kentucky-Tennessee Section Meeting, Owensboro, Ky., by Nick G. Johnson, Asst. Director, Div. of Public Health Eng., State Dept. of Health, Louisville, Ky.

TO understand and appreciate fully the present status of public water supplies in Kentucky, it is necessary first to examine what is happening to the state as a whole. Kentucky is undergoing a transformation brought about by an era of industrial evolution. The sudden industrial expansion throughout the entire nation in wartime has since gradually subsided in many parts of the country, but not in the South and especially not in Kentucky. Industry, big and small, has been locating, not only around the Louisville, Ky., area, but in and around smaller communities all over the state. The magnitude of this growth is indicated by the following quotation from a business journal (*1*):

> According to figures compiled by the Bureau of Foreign and Domestic Commerce, the total assessed valuation of the whole Commonwealth of Kentucky in 1937 was $2,400,000,000. The value of new and expanded industry which moved into Kentucky last year [1951] alone totaled nearly half that amount—$1,054,809,400. In 1951 Kentucky stood second to Texas among all states in the amount of plant construction. And experts in the field of industrial development claim that this is only the beginning of a great industrial expansion, which will make Kentucky and the Ohio River Valley "the Ruhr of America."

This tremendous economic expansion cannot help having very profound effects on the lives and well-being of the people. Among the many facets of activity affected are private and public utilities, including water supplies. Adequate and safe water supplies are necessary in the development and maintenance of a healthy and progressive communal and industrial existence. One of the most important factors responsible for attracting industry to Kentucky has been the abundant supply of surface and underground water. Most of the larger cities and towns have first-class water plants; many of these have or are planning to remodel, extend, and improve their present facilities to keep up with the increasing demands placed on them by industry and growing population. It has been stated that approximately half of all water treated by public water systems is delivered to industry, a fact that demonstrates how vital a part water resources play in the economic development of a region.

Even in communities of 3,000 population or less—the fifth- and sixth-class towns with the great majority of Kentucky's water plants—where industrial expansion has not been an influence, another force has been responsible for effecting progressive changes.

This factor is the desire of the people to build a fine community, one in which they will be able to enjoy all modern conveniences and comforts, including a safe and plentiful water supply. This desire, or state of mind, has been slow to develop because it must be brought about by a long and tedious educational process. The final results, however, are gratifying. Only a few years ago the attitude of residents and officials of small communities with poor or nonexistent public water supply facilities was: "What was good enough for our fathers and grandfathers is good enough for us." Today these people ask: "Please tell us what we can do to improve our water supply."

Water Works Statistics

The population of Kentucky is approximately 3,000,000, of which about 1,250,000 (or 40 per cent) is served by public water supplies. The remainder of the population is principally rural, widely scattered, and served by individual wells and springs. Of the 288 public supplies, 157 are municipally owned and 131 privately owned. The state and certain large private institutions serving the public own eighteen of the latter.

Surface sources are used by 171 systems and wells by the other 117. Of the systems with well supplies, 49 have automatic chlorination, while the rest employ manual chlorination or none at all. Practically all of the ground water supplies are deep wells, and there is very little chance of contamination. In some sections of the state, where underground limestone formations are prevalent, a special effort has been made to provide chlorination for the well supplies. Of the 171 surface supplies, 165 are given complete treatment, including coagulation, settling, and filtration. All of these use rapid sand filters, and five have pressure filters. Five of the systems with well supplies also employ pressure filters. Of the six small surface supplies without filtration, two are now building treatment facilities and the others are planning to do so.

The state health department rates every water supply either "good," "doubtful," or "bad," depending on the degree of treatment, protection of finished water reservoirs, existence of cross connections in the plant or distribution system, condition of equipment, and type of maintenance and operation. Of the 288 plants, 95 are rated good, 125 doubtful, and 68 bad. These ratings are subject to change one way or the other, following improvement or regression in the individual plant. Fifty-two plants submit monthly operating reports.

From 1948 through 1953 plans and specifications for 34 new water plants were approved by the state health department. Of these, 24 have been completed. During the same period plans and specifications for improvements, remodeling, and extensions to 58 existing plants were approved, with 44 completed. Also approved were extensions to 38 distribution systems, 34 of which have been completed. In addition, fourteen miscellaneous projects, such as impounding dams and booster stations, have been constructed.

The program for the fluoridation of public water supplies in Kentucky was enthusiastically received when it was first introduced. It is continuing to receive ever growing support and acceptance. The first fluoridation installation was made in April 1951, and the number grew to nineteen in 1953, in-

cluding Louisville. Other communities are in the process of obtaining approval. Of the 1,250,000 people in the state using public water supplies, more than one-third are now drinking fluoridated water.

Conclusion

Despite the record of progress, there is still much that needs to be done. Plant ratings must be raised. An increase in the number of plants now submitting monthly operating reports is desirable. An alarming number of the smaller plants are handicapped by the lack of properly trained personnel. This is a serious problem. It is hoped to improve the situation through short courses and other types of training programs. The deficiency of experienced personnel may partly be attributed to the fact that smaller communities do not pay enough to attract trained men. Many of the operators of these plants find it necessary to perform outside jobs, in order to supplement their income. Salary increases for these men would enable them to devote most or all of their time to the water plant.

Shortcomings and inadequacies admittedly exist, but the overall progress made in the water works field in Kentucky during the past few years is unusually good, and it is encouraging that the pace of improvement is steadily accelerating.

Reference

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Determination of Water System Improvements

By Jasper W. Avery

A paper presented on Sep. 10, 1953, at the Ohio Section Meeting, Cleveland, Ohio, by Jasper W. Avery, Partner, Havens & Emerson, Cons. Engrs., Cleveland, Ohio.

THIS paper will attempt to give some idea of the procedures and analytical methods used in developing a program of water system improvements. Included also are a few suggestions on design. The examples employed are drawn from a rather comprehensive study of one utility, and it will be appreciated that conditions will differ in other systems. The ratios and factors to be used must be determined for each system individually, although the general procedure followed is applicable to all.

The adequacy of any water supply system is judged by its ability to deliver water of satisfactory quality, in sufficient quantity, and under proper pressures, to meet the domestic and industrial demands of the area during the maximum hour on a maximum day, as well as to provide proper fire protection.

The first important step in an investigation of a system is to estimate its future requirements. This involves determining the area and population to be served and the total quantities of water to be used, including: [1] the metered domestic and industrial consumption; [2] the free water to institutions and public buildings; [3] the average daily amount to be pumped or delivered into the distribution system; [4] the amount to be pumped or the demand on a maximum day of the year; [5] the consumption or demand during a maximum hour on that maximum day; [6] the consumption or demand during a minimum hour on that maximum day.

Both short-range and long-range future requirements should be determined. The estimated needs 15–20 years hence can be used to fix the size of filtration plants and pumping stations—facilities that can be readily enlarged as required; the long-range estimate, for perhaps 50 years, can be used as a basis for the size of intakes and large feeder mains, which cannot be economically expanded or duplicated and must, accordingly, be designed large enough to be adequate for a long period.

The area to be served should be carefully outlined, and thought should be given to the possibility of future annexation or service to outlying sections. Population trends for the service area must be studied and forecasts made for the two periods in the future. The gross area is subdivided into census tracts or wards, and population forecasts are made for each.

Past records of water consumption are analyzed to determine the domestic usage, the amount of large commercial and industrial metered consumption in each census tract, and the quantity of

metered free water for institutions and public buildings. Records of the average daily amount pumped into the distribution system are then studied to determine the ratio of the average daily

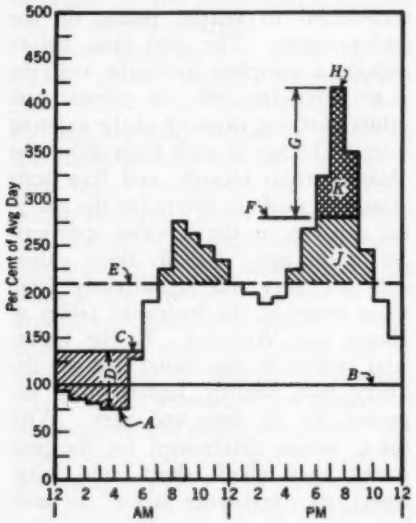

Fig. 1. Maximum-Day Load Curve (Typical Residential System)

Key: A—*minimum hour, 75 per cent (7.5 mgd)*; B—*average daily rate, 100 per cent (10 mgd assumed)*; C—*minimum-hour pumping rate, 135 per cent (13.5 mgd)*; D—*maximum rate of fill, 60 per cent (6.0 mgd)*; E—*maximum-day average rate, 210 per cent (21.0 mgd)*; F—*maximum-hour pumping rate, 280 per cent (28.0 mgd)*; G—*maximum rate of draft, 140 per cent (14.0 mgd)*; H—*maximum hour, 420 per cent (42.0 mgd)*; J—*clear well storage, 30 per cent (3.0 mil gal)*; K—*storage required, 15 per cent (1.5 mil gal)*.

pumpage to the metered consumption. This figure may vary from 1.1:1 to as much as 1.5:1; that is, the unaccounted-for water may vary from 10 to 50 per cent of the metered consumption, depending on the system. The unaccounted-for water includes losses due to leakage and underregistration of meters, water used for fire and flushing, and the like.

Also from past records, the pumpages on days of maximum delivery are found, and the ratio of maximum-day delivery to average-day delivery is obtained. This ratio may vary from 1.3:1 to 3.0:1, or from 130 to 300 per cent of the average day, again depending on the system. In a system containing a large percentage of commercial and industrial loads, the ratio will be in the lower range; for example, in the low-service district at Cleveland, Ohio, it is about 1.3:1.

Load Curve

It is very important to know how the hourly demand varies during a maximum day, as this factor has a definite influence on the size of the facilities that must be built. The maximum-day load curve (Fig. 1), a very useful tool in determining capacity requirements, shows the hourly variations in demand on that day. These hourly variations are obtained by compensating the hourly pumpages with synchronous hourly variations in the water level of any tanks and reservoirs. From such a chart are obtained the maximum-hour and minimum-hour demands, the maximum-hour rate of draft from elevated storage, the minimum-hour rate of fill into this storage, the firm pumping capacity, the amount of elevated storage required, and the amount of clear well storage required at the filter plant and pumping station. It will be seen that, in the particular instance for which this chart was prepared (the third high-service district

in the Cleveland metropolitan system), the maximum hour (Fig. 1, *H*) is 420 per cent, or 4.2 times the average daily rate, which is typical of a strictly residential system, although the figure has been known to go as high as 600 per cent.

The cross-hatched area (Fig. 1, *K*) above the line denoting the maximum-hour pumping rate (*F*) indicates the amount of elevated storage required for the system. The area (*D*) under the minimum-hour pumping rate line (*C*) is equal to this upper area (*K*); otherwise the elevated tank would not get filled by morning. For this particular system, the elevated storage required is 15 per cent of the average-day delivery. Actually, the storage required for the hourly fluctuations is approximately 10 per cent, but it is felt that, at the end of the sprinkling load, the tank should be not less than approximately one-third full, for fire protection.

The area between the maximum-day rate (*E*) and the maximum-hour pumping rate (*F*) is a measure of the clear well storage required at the filter plant and pumping station.

To make these evaluations more specific, assume that a residential system of this character has an average daily load of 10 mgd. The filter plant, then, would be designed for 21 mgd, with a 3-mil gal clear well, and the pumping station would have a firm capacity of 28.0 mgd. (The firm pumping capacity of a station is defined as the capacity with the largest pump out of service.) Storage, to be located preferably at the other end of the system from the pumping station, would generally consist of a 1.5-mil gal elevated tank.

Having thus determined the maximum- and minimum-hour conditions from the maximum-day load curve, the local demands of each census tract or other unit of area are calculated. Then a map of the existing and projected pipelines (generally those 12 in. and larger) is superimposed over the census or ward map, and the demands are transferred to nearby points on the feeder mains. The next step, before making a complete hydraulic analysis, is to determine both the present and future carrying capacity of the existing lines. The age of each main should be obtained from records, and flow tests should be made to determine the carrying capacity or the *C* value appropriate to the age. Usually these values will not vary too significantly from those given in the hydraulic tables of Hazen and Williams. In the Cleveland system, it was found that the delivery was slightly higher than expected, for all sizes and ages. With the *C* values determined for the projected ages (both short- and long-term), the "resistance factor" for each line can easily be found from tables. This factor is the loss of head for a flow of 1 mgd through 1,000 ft of the main. The head loss for each main will accordingly be the product of the unit factor and the number of thousand feet of main.

Hydraulic Analysis

Using the data obtained as described above, a complete hydraulic analysis of the system is made, covering minimum- and maximum-hour conditions for the long- and short-term future. Inasmuch as feeder mains should, for reasons of economy, be designed to serve for at least 50 years, it is necessary first to analyze the system for that period, thereby making certain that any new feeder mains or elevated storage will be large enough to satisfy ultimate de-

mands. Then the short-term analysis determines what portion of the ultimately required facilities will be necessary for, say, 15 or 20 years. Ground storage and pumping capacity can be designed on the latter basis, as they can be readily enlarged.

These analyses are made by the Hardy Cross method, which essentially involves the distributing of flow through multiple conduits by assuming the quantities and directions of flow in each line of the system, and then computing the losses to see if the assumptions result in a balanced-head condition in each loop. Adjustments are made in the flow until the loss of head around each loop does balance. Sometimes six or eight corrections are required before a balance is attained. Carried out manually, the procedure is laborious and time consuming. Recently developed equipment, however, has materially decreased the work.

McIlroy (*1*) of Cornell University noted that, when direct current is passed through a ribbonlike resistance or filament enclosed in a tubular bulb, the voltage drop across this nonlinear resistance, or "fluistor" as he calls it, varies as the 1.85 power of the current flowing through it, which is exactly the relationship that obtains between the loss of head and the quantity of water flowing in a main. Based on this fact, it is possible to construct an electrical analog of a given water distribution network. Each main is represented by an electrical circuit containing a socket in which is inserted a fluistor equivalent to the resistance factor of the main in question. Sources are represented by d-c inputs into the system at the proper points, and loads or takeoffs are represented by d-c grounding or takeoffs at the designated connections, with adjustment to the correct values by rheostats. Once the analog is set up—a process that may require 1–5 hr—it is a simple operation to take the ammeter reading and the voltage differential across each circuit and, by using the proper factor, to convert these readings into flow and loss of head in each main. With this device, the working time is reduced to less than one-tenth of that needed for manual computation. As an example, the Cleveland system had 24 separate problems to be analyzed, a task that would have taken six men about 6 months to accomplish manually; using the McIlroy analyzer, two or three men were able to complete the analyses in less than 3 weeks. Another advantage of the analyzer is that a quick check can be made to see that the pressure at the highest ground elevation in the system does not go below the minimum required—30–35 psi for a residential area and 40–45 psi for a commercial or business district. If it goes lower than these values, a larger new main is necessary. It is a matter only of minutes to replace a fluistor with one representing a larger main and to take another set of readings, whereas manual analysis would require 2–3 days of detailed computations.

Employing the results of the hydraulic analyses, maps showing recommended improvements—including such data as size and location of mains, pumping stations, and storage facilities, projected flows and pressures, and hydraulic gradients—are prepared. It is then comparatively easy to devise an improvement plan and construction program to keep step with future needs.

General Suggestions

Investigations and studies of distribution systems indicate that all new

mains should be designed to preserve high carrying capacities over a long life and to provide ample protection against corrosion. For feeder mains 24 in. and larger, it is suggested that alternate bids be taken on concrete cylinder pipe, prestressed concrete cylinder pipe, and steel pipe, with felt-wrapped exterior coating and cement or spun bituminous interior lining. Under present conditions, cement-lined cast-iron pipe is generally not competitive in these larger sizes. For local mains 16 in. and smaller, however, cement-lined cast-iron pipe is always preferable to coal-tar lined pipe, because the former will maintain a high carrying capacity. Sand backfill around a main and at least 6 in. over the top will provide a good cushion, reduce bending stresses, help minimize corrosion, and prevent later settlement of the pipe. For all mains laid under permanent pavements and sidewalks, it is good practice to have the trench completely backfilled with sand to prevent future settling.

For feeder mains larger than 24 in., consideration should be given to the use of cone valves, three sizes smaller than the main, with a well designed increaser after the valve; or else, double square-bottom gate valves, one size smaller than the main, should be adopted. The cone valve has the advantage of requiring fewer turns to close, being easy to operate, and needing no bypass valve. The chief disadvantage is that it costs considerably more than the standard double-disc valve. To provide for emergencies necessitating quick shutoff of the main, however, the added expense may be justified.

In the design of stations housing electrically driven pumping units, it is important to guard against the surge or water hammer that is sure to come when a power failure occurs. Pumping units capable of operating at 25–50 per cent overspeed backwards, as well as automatic cone check valves capable of closing at two different speeds, are recommended for large installations.

Large, quick-opening air inlet valves, with small air-release valves, may be required on large steel mains to prevent a vacuum that may cause their collapse if there is a power failure.

It is hoped that this paper has helped to make clear some of the procedures and methods involved in determining water system improvements.

Reference

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Oil Pipeline Failures and the Water Industry

Panel Discussion

A panel discussion presented on May 26, 1954, at the Annual Conference, Seattle, Wash.

Morrison B. Cunningham

Supt. & Engr., Water Dept., Oklahoma City, Okla.

WITHIN a few months after the discovery of oil at Oklahoma City, Okla., in 1928, approximately 400 wells had been drilled in the eastern half of the city, many of them in the vicinity of storm and sanitary sewers. Miles of oil pipelines had to be laid under the streets, at locations carefully selected by city authorities. Municipal permits were required and inspections were made to insure that existing utility structures were not disturbed any more than was necessary.

In a few years underground leakage began to appear, with the result that oil would enter the sewers, some of it reaching the sewage treatment plant, where it caused considerable difficulty. Because of the profusion of oil lines belonging to different companies—as many as 25 or 30 lines in a 400-sq ft area—the identification of an offending pipeline proved a serious problem. Eventually the various companies formed a committee which the city could notify of suspected oil leakage in a given locality. One of the companies with lines in that section would then undertake the required excavation and repair, and the company whose line turned out to be at fault would later pay the cost.

Gas and crude-oil pipelines from a recently opened oil field traverse the drainage area above the city reservoir. State law has enabled the city to adopt an ordinance covering sanitation, and fine cooperation has been received from the oil companies concerned. Valves have been installed on the lines at the points where they enter and leave the drainage area. In the past the oil companies have objected to this practice, for fear that the valves might not be able to withstand the tremendous pressures developed during pumping. In this instance, however, the design of the pipelines and pumping facilities was worked out jointly by the utility and the oil companies to permit the use of valves.

The water department has been given the keys to the valves and has the authority to close them if a break occurs, thus shutting off the flow of oil or gas and preventing undue damage to the reservoir supply. Particular care has been taken by the city to insure that, in such an emergency, it will be possible to identify the proper line to be shut off.

In the drainage area, in the immediate vicinity of the reservoir, the city has constructed an auxiliary earthen reservoir. The latter is normally dry and the outlet closed, so that, in the event of an oil line break, the contents would flow into it and be pumped out with no harm to the water supply.

In addition to the safeguards already mentioned, the city maintains a constant patrol of the watershed. Consequently, it is believed that fairly good security is being provided. Up to the time of this writing, no oil contamination of the water supply reservoir had occurred.

John C. Detweiler

Gen. Supt., Water Operation Dept., Metropolitan Utilities Dist., Omaha, Neb.

All of the water supplied to Omaha, Neb., through the treatment and distribution system operated by the Metropolitan Utilities Dist. of Omaha is taken from the Missouri River at a point approximately 8 miles upstream from the heart of the city. Several petroleum products pipelines, both aerial and submerged, cross the Missouri River above the Omaha intake, the closest being near Decatur, Neb., about 60 miles upstream. The rather incomplete information presently at hand indicates that there have been several pipeline failures at these river crossings during the past few years, although the break in August 1953 is the only one whose effect on the Omaha water supply has been recorded in detail. On Aug. 4, 1953, a number of consumer complaints were received regarding an oily taste in the finished water or an oil sheen on the surface. Surprisingly, no evidence of contamination had been noticed at the treatment plant, although the complaints were widely distributed over the system. It was learned that the Council Bluffs, Iowa, water system, which also takes water from the Missouri River, was receiving similar complaints. In an effort to determine the cause, the chemists of both plants jointly undertook an investigation, with the assistance of an Iowa public health department engineer who happened to be inspecting the Council Bluffs plant at the time.

There had been no report of leaks or failures at pipeline crossings above Omaha, or of spillage or wastage of petroleum products by contractors or Army engineers operating equipment on the river. Inquiry did reveal, however, that, during the morning of Aug. 3, a break had occurred on a 12-in. submerged pipeline crossing the Missouri River near Decatur, Neb. Two 12-in. and two 8-in. lines cross the river at this point. Apparently the break had been repaired, or the pipeline shut down, in a short time, but not before an estimated 40,000–45,000 gal of gasoline was discharged into the river. The pipeline company had not notified either the press or the industries or utilities that might be affected by the failure. In the author's opinion, the pipeline companies should assume the responsibility of publicizing such occurrences, so that those concerned can take steps to cope with the inevitable problems that develop.

Omaha attempted to alleviate the oil taste and odor trouble by applying moderate amounts of activated carbon. This method was not effective, however, owing to the fact that the contamination of the raw water by petroleum materials took place in a short length of time and was not detected at the treatment plant before the distribution system was affected. Prior notice of such an emergency would give the water operator a better chance to deal with the problem.

During the investigation of this pipeline failure and the attendant tastes and odors, it was learned that breaks had previously occurred on several other lines above Omaha without causing difficulties at the water plant. The ab-

sence of trouble on these occasions may have been due to the nature of the petroleum product lost during the break, a high dilution factor resulting from a large river flow, or the presence in the raw water of materials that adsorbed or neutralized the effects of the oil product. It is evident that such favorable conditions may not always exist in the river during future pipeline breaks, with serious consequences to the water utilities. Hence, it is extremely important that they be notified of oil line failures soon enough to take proper measures.

Melvin P. Hatcher

Director, Water Dept., Kansas City, Mo.

The Kansas City, Mo., Water Dept., which serves 650,000 people, obtains its supply from the Missouri River. The river water intake and treatment facilities, providing for clarification, disinfection, and softening, are located about 4 miles upstream from the city. At about 8 AM on Oct. 2, 1953, the operating personnel of the treatment works became aware of a strong gasoline odor in the water. A little later complaints began coming in from users. A telephone call to Kansas City, Kan., brought out that there was no trace of the difficulty at the latter's intake, which is about 3 miles upstream from the Kansas City, Mo., intake. At about 10 AM a call was made to an oil pipeline company known to have the only petroleum products line crossing the river at a point between the two intakes. The company's public relations officer had no explanation for the trouble that was being encountered. By noon complaints were coming into the city hall switchboard at a rate that required the use of six or seven phones. In midafternoon of the same day the pipeline company official called to say that pressure records had indicated leakage somewhere between Kansas City and Omaha, Neb., and that the line had been shut down during the evening of the day before, but he did not know exactly when.

Throughout the remainder of the day water works employees devoted themselves to plant cleaning operations, which consisted chiefly of removing the top 4-in. layer of filter sand and hosing the side walls of the filters. Consumer complaints continued at a high rate. When, at about 5 PM, it appeared that uncontaminated water could be delivered to the distribution system, hydrant flushing operations were begun, with about 45 hydrants open at one time. Later, about 8 PM, the pipeline official reported that more gasoline had spilled into the river. This time the intake pumps were stopped for about 2 hr, thus avoiding the greater part of the contamination. With the shutdown of the plant, the demands for water made it necessary to stop the hydrant flushing operation.

On Oct. 3 the volume of complaints was the same as on the day before. Hydrant flushing, begun about noon, was continued until about 4 AM the following morning, with as many as 55 hydrants flowing at one time. Pranksters found during this period that they could open hydrants without running the normal risk of detection. It took several hours to locate and close the 35 hydrants opened illegally.

During the period of heaviest gasoline concentration in the water being treated, the effluent delivered to the distribution system contained about 0.5 ppm of gasoline, the filters bearing the brunt of the contamination. The emulsified oil particles penetrated about 4 in. into the sand and would not wash

off. It required a crew of 45 men working for 12 hr—approximately 540 man-hours—to remove this surface layer of sand.

There have as yet been no hearings or court proceedings of a scope that would allow for a complete explanation of the pipeline company's actions in connection with this contamination of Kansas City's water supply. It appears necessary, however, as a part of any report on the incident, to call attention to the fact that the company did not act as promptly as it should have in notifying those using the river as a source of supply. Present records indicate that the pipeline company had reason to believe sometime on Oct. 1—presumably late in the day—that the line had failed. Whether the company was aware that the break was at a river crossing is not known, but it does not seem unreasonable to say that it should have suspected a river crossing failure and should have warned Kansas City and others using the river for water supply. It would seem, unless mitigating circumstances can be cited, that the oil pipeline company was grossly unmindful of its obligations to the water-consuming public.

The pollution of Kansas City's water supply in this instance led to increased interest in the threat posed by pipeline crossings above the city and, particularly, to an awareness of the almost complete lack of control, from a pollution standpoint, over their design and operation. As far as the author has been able to determine, there is no federal agency, and no state or local agency in Missouri, that can prescribe standards of design and operation for such crossings. The US Army Corps of Engineers issues permits for crossings, but its authority is related to the needs of navigation. Federal and state health agencies appear to lack the specific authority necessary to prescribe preventive or corrective measures. The Kansas City incident seems to indicate that there is a dire need for greater controls.

API Committee Statement

A statement prepared by a special committee appointed by the chairman of the Central Committee on Pipeline Transportation of the American Petroleum Institute. The members of the special committee were: R. K. Paine (Chairman), C. C. Keane, R. H. Lynch, E. F. Morrill, A. E. Pecore, and L. F. Scherer.

The pipeline section of the petroleum industry is nearly as old as the industry itself, the first successful pipeline having been constructed in 1865. In the last 10 years oil line construction has averaged approximately 5,000 miles annually, and, at the end of 1952, a total of 171,000 miles existed in the United States. During 1953, 3,440 miles of new petroleum product pipelines was constructed, plus 4,650 miles of crude-oil pipelines, a total of more than 8,000 miles. With this great network of pipe, the industry moves a total of approximately 10,000,000 bbl per day of crude oil and products. In 1950, the latest year for which figures are available, oil pipeline traffic amounted to approximately 100 billion ton-miles, representing 12.8 per cent of the total ton-miles of freight transported in the United States by all methods, including railroads, trucks, Great Lakes tankers, and inland-waterway barges. Almost every single barrel of crude oil moving into United States refineries is at some time transported through a pipeline, and approximately 4 of every 5 bbl are actually delivered into the refinery by this means. Thus,

it is evident that pipelines are an important factor in the overall transportation facilities of this country. Because these lines are underground and seldom noticed, few people realize the volume of traffic that is handled, and it is not generally known that this vast movement of a vital product is completed, the committee believes, with a safety record second to none.

With so tremendous a tonnage passing through a vast network of pipe across a country as large as the United States and traversing thousands of acres of watersheds, some operating difficulties and unforeseeable accidents are bound to occur. These are of concern to both the petroleum and the water industry, as well as occasionally to the public at large, which the two industries serve. Such a situation—in which facilities that ordinarily function for the good of the public may, as a result of malfunction, adversely affect the "public interest"—is not a new problem. The damage from a steam boiler explosion, the electrocution of innocent bystanders by fallen power lines, and the death of persons on the ground as the result of airplane crashes in municipal areas are all cases in point. There is a fundamental rule in classical economics that states: "When the good accruing from an operation, in the opinion of the public, offsets the bad, then the public will approve and use the product of that operation as long as that product is economically attractive."

The fact that oil and product lines are a possible source of trouble to municipal water and sewerage systems is frankly acknowledged. The committee believes that, if the AWWA and the API will consider this problem jointly, as they did the problem of underground corrosion a few years ago, it will be possible to arrive at an acceptable solution. It is further believed that this problem should be approached with imagination, ingenuity, and a genuine spirit of cooperation like that exhibited on several recent occasions when the pipeline industry cooperated with the public in supplying water to municipalities and outlying areas that were in dire need.

Oil Line Design and Operation

Although this panel discussion is concerned primarily with oil line stream crossings, it is believed worth while to review briefly the general design, construction, and operating features of such pipelines. Oil and product lines are conservatively designed. The stresses recommended in the ASA pressure piping code are, to the best of this committee's knowledge, adhered to by all pipeline companies. In fact, many companies use factors of safety in design even more conservative than the ASA standard.

In addition—depending upon the size and location of the line, the possibility of exposure to corrosive soils, and so forth—the industry employs a number of other protective measures, many of which are familiar to the water works operator. The most important of these is pipeline coating, using coal-tar enamel, asphalt or an admixture, or some other corrosion-resistant material, sometimes with glass fiber reinforcement and impregnated asbestos felt wrapping. Another common device for protecting the pipe is cathodic protection, through the installation of magnesium or zinc anodes or the use of rectifiers. Most pipeline companies maintain competent corrosion engineers who constantly study the changing surface and subsurface conditions and the exposure of pipelines to other underground structures, and who strive to

protect the pipeline at all times from any detrimental internal or external action.

Another protective or safety practice common in the industry is pipeline patrolling, either by foot or in small, low flying airplanes. These linewalkers and pilots are constantly on the alert for indications of small leaks, soil erosion that may endanger a line, movement of river banks or bars, the proximity of construction machinery or road graders, and any other condition that may result in leaks or damage to a pipeline. (It seems appropriate to mention at this point that the construction standards and specifications in the petroleum industry require a line to be absolutely tight at or above the operating pressures, and no allowance of any kind is made for leakage.)

In the design of crude-oil and product pipeline pumping stations, the petroleum industry utilizes many protective devices, not only to safeguard its equipment and employees but to fulfill its obligation to the public. Every safety feature has its proper place and use, depending upon the size and length of the line, the pressures involved, the product being handled, the nature of the operation, and the economics of the situation. The devices used include pressure, temperature, and flow controls that alert the operator on duty or even shut the station down when there is some perceptible leak or malfunction at the station or along the line; safety valves that relieve unusually high pressures by drawing off the flow into tanks; and time limit switches that keep the magnitude of pressure surges within predetermined safe bounds when valves are being opened and closed.

Privately owned and leased communication systems, covering the entire operating area, are another important safety factor, permitting headquarters to be in constant touch with the pumping stations. Thus, in a given area, all persons concerned are thoroughly familiar with the operating conditions at every station. Frequent regular checks are made of quantities and pressures, from which it is possible to determine promptly if there is any perceptible leak, break, or other malfunction. It is noteworthy that oil and product pipeline companies shared in the development and use of private telephone and telegraph lines and leased teletype facilities, and pioneered in the use of microwave radio. Up until very recently the most extensive microwave radio system in the world was one operated by an interstate oil pipeline company.

Stream Crossings

In the original aerial and ground survey for a proposed pipeline, all rivers, streams, and lake crossings are noted. As soon as the final route is determined, survey crews and engineering teams go to these crossings to study the land features and obtain as much underwater information as possible. For rivers of major size and importance, it may be desirable to learn the underwater profile, check the type of soil on the banks and in the bed, secure meander maps covering a period of years, and compile data on high- and low-water marks, flood areas, specific gravity of water in the river, rate of scour, rate of deposit, sand and silt content, and corrosive effect. The experiences of other pipeline companies in crossing the river are reviewed. Frequently, it is necessary to secure the consulting services of river-crossing experts and governmental agencies, like the US Army Corps of Engineers. The pipeline engineers, after having thoroughly

studied the foregoing data and considered the stipulations of any agency with jurisdiction over the crossing, develop a design satisfying all requirements. It should be pointed out that lesser waterways and small rivers may require little design work, if any, whereas major river crossings may take months of investigation. Such studies will determine the direction in which the line ters, numerous jurisdictions may be made for depth of scour line and general meandering, the need for revetments, dredging, and bridges, and the like.

The completed design must be presented to the regulatory body having jurisdiction over the waterway involved. For example, all navigable waters are under the authority of the US Army Corps of Engineers, and crossings are subject to its requirements and inspection. Permission for making such crossings is not granted until all interested parties have been advised and public notice of the request has been given. For nonnavigable waters, numerous jurisdictions may be involved, including: the US Fish and Wildlife Service, Corps of Engineers, Coast Guard, and Bureau of Fisheries; state game, fish, and oyster commissions, conservation departments, land offices, forestry boards, and water policy commissions; irrigation and flood control authorities; county commissioners; police juries; boards of commerce and navigation; rivers and harbors organizations; port authorities; water districts; city commissioners and water utilities; and individual property owners. Where crossings come under the jurisdiction of regulatory bodies, public hearings to discuss proposed plans are usually provided for. Newspaper advertising and the mails are frequently employed to inform interested parties.

Even after a crossing has been designed, a right-of-way secured, and construction completed, it is sometimes necessary to make further hydrographic surveys from time to time in order to study the effect of manmade changes, as well as the natural meanderings of the river, sloughing of the banks, and movement of the bed. Sharp deviations in the course of a river may take place almost overnight during periods of extreme high water, but it is customary to observe the long-term meanderings so that preventive measures can be adopted where required.

Although river crossings may be designed with the utmost in engineering and metallurgical skill, incorporate all known safety precautions, and involve the expenditure of millions of dollars, it is possible that a river, in its meandering or scouring, will completely destroy a crossing literally in a day. Recently a pipeline company spent $1,000,000 laying a line under the channel of a major river deeper than the lowest known scour point. During a subsequent high-water period, however, the river scoured 25 ft below the previous maximum depth and caused the line to fail. In another instance, a major pipeline company spent an equally large sum, only to have the river change its course and meander laterally for almost a mile, with a resultant break in the pipeline and loss of product into the river. This sort of accident cannot be foreseen.

One might ask why pipelines are not carried over rivers instead of under them. Recently a company was given a rough estimate of $20,000,000 for the construction of an 8,000-ft suspension bridge, compared with $1,000,000 for an underwater crossing. Even where physically and economically practicable, bridge crossings are usually not pre-

ferred to subchannel crossings because of the increased contingent liability, increased exposure to hazard, particularly in time of war, and difficulty in securing permission from owners or authorities having jurisdiction. An underwater crossing is usually safer than a bridge crossing unless there is a history of severe meandering and uncontrollable bottom movements. Some short-span aerial crossings, however, have proved successful.

It is true that gas companies have made extensive use of aerial crossings, but gas lines handle a product weighing very little per lineal foot, whereas an oil product may weigh more than the pipeline itself. This substantial difference in the weight of the product handled works to the economic detriment of aerial crossings for oil lines.

Pipeline Breaks

The foregoing general description of oil pipeline design, operation, and construction practices has mentioned the precautions taken by the industry out of respect to its obligations to the public. It must be admitted, however, that, in spite of good practice, accidents may occur from time to time. It is important to note that the two pipeline breaks discussed by other members of this panel involved the horizontal meandering of a major river. In both instances, good design, engineering, and construction practices had been followed.

The design and construction of the river crossing near Omaha, Neb., was approved and inspected by the Army Corps of Engineers. Subsequently, however, that agency was forced by budget restrictions to discontinue maintenance of the river banks and channel. As a result, the river again followed its natural meanderings, which became so extensive that a bridge located upstream from the pipeline crossing and costing millions of dollars was left "high and dry." The river bed moved a distance of almost a mile. It is impractical, if not impossible, to provide for such extreme contingencies.

The break at Kansas City, Mo., was caused by a shift of the channel from one side of the river to the other. The original design and construction of this crossing involved the installation of two lines as an added safety precaution, at considerable expense to the pipeline company. This crossing also was approved and inspected by the Corps of Engineers, which maintained the banks of the river. Unfortunately, however, it is not possible to control the meanderings of a river channel completely, even within its banks.

In another incident reported (*1*), at Batavia, N.Y., the loss of petroleum product was caused by a valve failure in the normal operation of the pipeline. It is pertinent to point out that the valve was located at that particular site because of a mandatory requirement of a regulatory body having jurisdiction over crossings in the area. The company would not normally have installed a valve at that location, as it was not considered good practice even then. For the record, it should be pointed out that no undue internal stresses or "water hammer" was involved in this failure, as has been implied in some published statements.

The petroleum industry, like any other progressive one, is constantly striving through research and development of its own, together with the use of improvements made in other industries, to design, construct, and operate the component parts of its system as best indicated by the most advanced scientific and engineering knowledge.

When new instrumentation, improved metallurgy, or any advancement in engineering is made available, it will, if applicable, be incorporated into oil industry procedures.

The tremendous investment in crude-oil and product pipeline facilities can be justified only on the basis of sound business practices, which require a high operating level and an earning power in proportion to the capital involved. When a failure in a pipeline or its component equipment makes it impossible to "keep the oil moving," it is obvious that all revenue stops completely, while expenses continue or actually increase. Therefore, the pipeline company has a substantial financial interest in preventing all failures that would result in the interruption of the movement of oil or products through its system. This interest stems not only from the desire to prevent loss of revenue but also from the fact that repairs to a pipeline are costly. River crossing repairs, in particular, are very expensive, as they are made under emergency conditions, and they frequently cost more than the original installation. Consequently, the petroleum industry has, if possible, even a greater interest than the AWWA in providing maximum safeguards and protective devices to prevent service interruptions. Such measures are, of course, equally in the public interest. Likewise, any safety device or practice required for the protection of the general public, if not impractical or detrimental to the actual operation of a pipeline facility, is regarded as beneficial by the pipeline companies.

Joint Action

The problem of oil line breaks affecting water supplies is not a great deal different from that experienced by many pipeline and utility companies in municipal areas where the installation of cathodic protection by one company works to the detriment of another. For example, the telephone companies, in applying cathodic protection to their lead sheath cables, inadvertently caused damage to adjacent subsurface structures. Such problems were mutually resolved in 1948, when the AWWA and the API formed the nucleus of a correlating committee for joint cathodic protection.

It is, therefore, suggested that the problem of oil line breaks can also be met by a joint approach. In many urban areas, there are already in existence joint committees on which representatives of oil line companies and water systems work together with others to solve their common difficulties. Through these committees, it may be possible for the members of AWWA to familiarize themselves with the location of any pipelines that traverse the watershed and drainage areas of their particular supply. All pipeline companies will be more than happy to cooperate in the dissemination of the necessary information. Joint surveys could then be undertaken to acquaint both parties fully with the conditions existing in the area. Where such joint committees and contacts are not already established, it is suggested that the members of AWWA initiate contact with the local pipeline companies because the former's knowledge of watershed and drainage areas is not, in general, shared by pipeline companies.

A further benefit to be derived from such joint action would be the setting up of a system whereby affected utilities could be promptly informed of a line failure in order to permit them to prepare for the emergency and to follow out plans carefully drawn up in advance.

The API can promise the cooperation of the managements of the pipeline companies in the United States. This committee is quite certain that, as a result of the fact that the two industries are already working together on the common problem of cathodic protection, the petroleum pipeline companies will receive with courtesy any overtures that may be made by members of AWWA. In many ways the oil industry has shown interest in its obligations to the general public, which the water utilities also serve. With this common background and common purpose, it is believed that there exist within the two industries the tools, engineering skill, and knowledge to solve their problems to the satisfaction of the public, the water works, and the pipeline companies.

Reference

1. Threat to Water Supply From Oil Pipeline Averted in Batavia, N.Y. *Taste & Odor Control J.*, **18**:11:1 (Nov. 1952).

Informal Discussion

After the preceding papers had been presented, a number of questions from the floor brought out some additional points of interest. A portion of the colloquy, taken from the stenographic transcript of the session, is given below in abridged form.

Q. Would it be feasible for an oil line to be fitted with automatic self-closing valves on one or both sides of a river crossing?

A. L. F. SCHERER [Asst. Gen. Mgr., Texas Pipe Line Co., Houston, Tex.]: We do install valves—but not automatic ones—at the high-water mark on either side of all major river crossings. Such valves, to be useful at all, have to be accessible. We do not install self-actuating valves, because, in the majority of pipeline failures, such valves would be inoperative through power failure. Poor accessibility also makes them impractical. We have for some time been investigating the possibility of using remote-control valves, but they have similar drawbacks. To date no manufacturer has been able to furnish a foolproof device.

It is no problem to stop the flow of oil once you are aware of where the break is or that there is a break. We shut the lines down—in fact, our stations shut down automatically on failure of pressure. So far we have found no automatic valve that we feel is safer than the present manually operated type. We believe that all automatic valves could, and very probably would, be shut down unexpectedly, owing to variations in pressure that occur constantly, and the resultant damage from surge would be far, far greater than any that might be even remotely anticipated from other causes.

Q. Is it the practice to install relief valves to control surge pressure in stations?

A. L. F. SCHERER: Yes, particularly in pipelines using reciprocating pumps. It is not generally necessary in pipelines using centrifugal pumps, because the latter are so designed that they do not overload the lines; thus, even if the line were blocked completely, the safe limit would not be approached.

Q. Isn't it possible to have a destructive surge due to a power failure?

A. L. F. SCHERER: Yes, that is possible if the facility is not properly designed. About 3 years ago, however,

the API undertook to make a very elaborate study to verify the various laws involved in water hammer or hydraulic compounding. Conclusive results were obtained that could be applied to pipeline design. All modern pipelines are now designed to make sure that valves are so timed as to prevent that sort of surge.

Q. How about the older pipelines?

A. L. F. SCHERER: Any first-class operating company is constantly reviewing its old facilities to forestall such troubles. Actually, the problem is not very great in lines less than 16 in. in diameter. We do not anticipate any difficulty, but we are examining all equipment that might be subject to such surges.

Q. Would failure at natural-gas pipeline river crossings result in the same difficulties as oil line failures?

A. L. F. SCHERER: Natural-gas lines are generally designed with safety factors almost equal to those in oil lines. The only source of gas contamination would be the relatively small quantity of condensation at the bottom of the sag in the gas line in the river. The amount would be negligible—50 or 100 gal of product at most.

Q. To what extent, if any, are pipeline river crossings regulated by government agencies?

A. E. A. SCHMITT [Chief, Water Supply Div., Washington Aqueduct, US Army Corps of Engineers, Washington, D.C.]: Perhaps I can answer that question, as I recently had occasion to check on the matter. It has been correctly stated that the Corps of Engineers inspects pipelines crossing a navigable river. Such inspection is nominal, however, because it relates only to clearance and does not deal with structural considerations at all.

During the course of my investigation, I learned that the Interstate Commerce Commission is concerned with the materials transported in pipelines, but not with the lines themselves. The Federal Trade Commission has no regulations on pipelines either, just a cursory interest in statistics on the subject. The same is true for the Oil Div. of the US Dept. of the Interior. The Bureau of Internal Revenue is interested only in the tax and depreciation aspects.

State and local authorities in the vicinity of Washington, D.C., likewise do not regulate pipelines, except to issue permits. There is absolutely no control or inspection of the structural features of pipeline river crossings—at least not by the agencies with whom I checked.

I think that this matter should be brought officially to the attention of the various agencies and the oil companies. If there is to be any control of pipeline river crossing design and construction practices, legislation will have to be enacted either by the states or by Congress.

AWWA Constitution and By-Laws Amended

Election of Directors

Amendments to two sections of Article IV of the AWWA Constitution, pertaining to the residential requirements of Directors and the filling of vacancies in the office of Director, were approved by ballot of the members as of Sep. 1, 1954. A total of 1,412 members returned their ballots. The vote on the two amendments was as follows:

Article IV, Section	Approved	Disapproved	Invalid Ballots
3.1	1,391	14	5
3.3	1,396	3	5

The difference in totals is explained by the fact that some members voted on only one of the amendments. Also, five of the members who returned ballots neglected to vote on either section.

The amended text reads as follows:

Sec. 3.1. One Director to represent each Local Section shall be nominated and elected by the members of the Section in the same manner as the Presiding Officer of that Section is elected. The manner of such election shall receive the approval of the Board. The Director so elected shall be an Active Member * of the Section. If he should cease to be a member of the Section before his term of office is ended, it shall be within the power of the Section to replace him.

Sec. 3.3. Whenever a Director representing a Section retires before his term is completed, the vacancy shall be filled: [1] by election by the Section members as prescribed in the By-Laws of the Section for the election of officers; or [2] by appointment by the Governing Body of the Section. The Governing Body of the Section shall have authority to appoint a successor Director only if an election in the manner prescribed in the By-Laws of the Section is not feasible for the reason that there will be no regular election of officers of the Section: (a) before the next regularly called meeting of the Association's Board of Directors; or (b) before the next regularly called meeting of the Governing Body of the Section.

The amendment of Section 3.1 removed the requirement that the Director must reside in the territory of the Section at the time of his election. This change permits a Hawaiian member affiliated with the California Section, for example, to be elected Director. In anticipation of the adoption of this amendment, the Board of Directors, on May 23, 1954, approved an addition to Section 2.1 of Article VII of the AWWA By-Laws. This section now reads as follows (amended portion in italics):

Sec. 2.1. Any member of the Association who resides in a locality which is not included in the territory embraced by an existing Local Section may, upon written request to the Board, be included in the membership of any Local Section. The Secretary of the Association shall notify the Secretary of the Local Section of the enrollment of the member. *When a member is added to the enrollment of a Local Section, such member may participate in all of the activities of the Section and shall be eligible to hold any office to which the Section may choose to elect him.*

* The term "Active Member," as used herein, includes Honorary Members, Life Members, Active Members, and officially designated representatives of Corporate Members or Municipal Service Subscribers, all of whom, by the terms of the By-Laws, have the privileges of Active Members.

Preparation for Peacetime Emergencies

By T. L. Vander Velde

A paper presented on Sep. 3, 1953, at the Michigan Section Meeting, Escanaba, Mich., by T. L. Vander Velde, Chief, Water Supply Section, Div. of Eng., State Dept. of Health, Lansing, Mich.

FOR several years the need to prepare for emergencies has been widely publicized, with special emphasis on bombings, particularly of the atomic variety. As impressive as the results of manmade catastrophes might be, attention must still be paid to the threat of natural disasters, which, though perhaps less destructive, are more likely to occur. Not a year goes by in which no part of the country experiences some type of emergency, with greater or smaller consequences. Preparation for such "ordinary" peacetime emergencies is a long step toward preparation for all disasters. The necessity for being ready to meet emergencies was well demonstrated by two recent tornadoes that struck Michigan within weeks of each other.

Port Huron Experience

The first storm hit the south side of Port Huron at 4:40 PM on May 21, 1953, causing a breakdown of power and communication lines. The water supply was affected in several ways. Uprooted trees broke a water main and several service lines. No water could be pumped for about 5 hr, owing to the power failure, and there were no standby facilities at the water plant. As a result, the two elevated storage tanks were so depleted that negative pressures were experienced on the distribution system. Pressure gages indicated no substantial pressure until about 7 AM on May 22. This combination of conditions led to the possibility of back siphonage of sewage into the distribution system. To safeguard the town, the following steps were taken:

1. An order was given to boil all water used for drinking and domestic purposes.
2. The chlorine applied to the water was increased to give a residual of 2.0 ppm.
3. Every hydrant was flushed on the night of May 22 to eliminate all old water standing in the mains since the power failure.
4. Satisfactory water was made available at the nearby Marysville Water Filtration Plant and from a tank truck located in Port Huron. (The water in the distribution system was not adjudged satisfactory until 12:30 PM on May 23.)

After a disaster of this kind, one wonders what might have happened under less fortunate circumstances. Suppose a fire had broken out during the power shutoff? Or suppose the direction of the wind had been different, increasing the turbidity and making adequate treatment impossible by reason of chlorine demands beyond the capacity of the chlorinators to meet?

It is conditions such as these that must be provided for.

Beecher Metropolitan District Experience

The worst tornado in modern times struck the Beecher area north of Flint at 8:20 PM on Jun. 8, 1953. The damage to homes and the suffering and loss of human life were almost indescribable. The three wells serving Beecher went out of service when the power failed. Although there were no known water main breaks, many service connections were broken. This situation resulted in the emptying of the 200,000-gal elevated storage tank and the entire distribution system. Back siphonage of contaminated water soon became imminent. The tornado cut through the middle of the distribution system, complicating the problem of restoring service. Finally, the water superintendent, Lynn Henderson, was injured and had to be hospitalized.

Work crews and water plant personnel from Flint, Mount Morris, Flushing, Grand Blanc, and other towns rendered valuable assistance. The following lines of action were taken to provide safe water to the area:

1. Handbills and a sound truck urged residents to use water sparingly and boil all drinking water.

2. A crew was organized to close the proper valves on the distribution system to shut off the damaged area. A record of valve locations kept by the water superintendent and maps prepared by the design engineers proved invaluable for this purpose.

3. One well was restored to service at 10 AM on Jun. 9, using a chlorinator to provide a residual of more than 5.0 ppm. Despite a flow rate of about 275 gpm, there was no increase in pressure in the empty distribution system.

4. By noon of the same day a hydrant on the Flint water system was connected to a Beecher hydrant through a fire department pumper and two hoses. A combination gasoline-electric hypochlorinator was used at that point to apply more than 5.0 ppm chlorine. Pressure in the Beecher system began to increase.

5. Valves on the distribution system were again manipulated to restore service north of the stricken area. Work details were organized to look for leaking services and to repair or cut them off. Twenty-five plumbers were made available from the Flint area to accomplish this objective.

6. Power was restored to a second well by 6 PM on Jun. 9, but various difficulties prevented the pump from being placed in operation until the next morning, although work continued during the night. A chlorine residual in excess of 5.0 ppm was maintained.

7. On Jun. 10 two crews were organized to flush hydrants. By 4 PM chlorine residuals of 1–2 ppm were present in all functioning parts of the distribution system. Precipitated iron, iron sulfide, and hydrogen sulfide in the mains made flushing operations very difficult and time consuming.

8. Power was restored to the third well and a new chlorinator installed by 5 PM on Jun. 10. The connection to the Flint system was maintained, but pumping was stopped.

9. At 6 PM on Jun. 10 the water supply was declared safe for drinking. The next morning most of the remainder of the distribution system was restored to use.

One of the lessons learned in this emergency was the importance of com-

munications facilities. Telephone service was interrupted for almost 24 hr. During that time all contact with civil defense headquarters had to be made in person, either by car or on foot. Communication with crews in the field would have proved very helpful, but two-way radio equipment was not available. (The author has recently been informed that the Michigan Office of Civil Defense will lend such equipment to the health department in emergencies.)

Essential Considerations

Experiences like those described illustrate vividly the need to prepare for disaster. A number of items should be given consideration:

1. Readily usable equipment records and distribution system maps are essential. Too many valve and main locations have been recorded solely in the head of a water superintendent who has long since departed, taking the information with him. Any of a number of mapping and recording procedures are satisfactory if they present a clear picture. A "Recommended Practice for Distribution System Records" has been published by AWWA (*1*). Accurate descriptions of pumping and other equipment are also necessary, so that replacements can be made with no loss of time.

2. Certain security measures can be taken, their extent depending on the nature, location, and size of the supply. Detroit has adopted a comprehensive plan for protecting its key facilities, safeguarding its records, and screening its personnel. Important operating units are under armed guard. In every system, facilities not receiving constant attention should be kept under lock, and unsupervised visits by strangers should not be permitted.

3. Duplicate or standby equipment is an important consideration. In this connection, it may be appropriate to quote an excerpt from the monthly report of one water works operator:

> JUN. 30; 2:30 PM. Lightning during a storm hit the power line just outside the plant. The wires lay burning on the ground until 6:30. The elevated tank was empty when we got started again. We were lucky again that we had no fires in the town during the time of water shortage. I have asked a dozen times for a generator and a motor to run it. Some day our luck will run out (this makes three times in 20 years).

Other operators are undoubtedly faced with the same problem. The need for duplicate or auxiliary equipment is very great, but it is hard to convince governing bodies of the fact.

4. Certain other equipment, such as emergency chlorination apparatus and testing kits, should also be available. Communications during a disaster are of the utmost importance. The use of two-way radio and mobile telephone has been of help in past emergencies. It is also well to consider the availability of tank trucks to be used to bring in water for minimum requirements. Many similar items could be mentioned.

5. When certain types of emergencies are anticipated, it may be wise to increase the chlorine residual in the water leaving the plant. A contaminated distribution system is much more easily cleaned up if continuous chlorination is practiced.

6. An inventory of available auxiliary water supplies should be made. Interconnections between two existing municipal supplies are often possible.

Sometimes a modest stockpile of pipe will make such connections feasible. In dire emergencies, industrial supplies might be used, and the quality of such water should be thoroughly investigated in advance.

7. Personnel is another item not to be overlooked in preparing for emergencies. Men, like materials, are subject to loss or attrition, and good quality costs money. Plans must take into account the possibility of accidents to key personnel, as well as to facilities like pumps or valves.

In the author's opinion, one of the prime accomplishments of the Michigan Section of AWWA is the training of personnel. Such programs have paid handsome dividends in emergencies. It can truthfully be said that a good start has been made in helping water works men become qualified operators, but these programs must be continued and expanded.

Serious attention should also be given to the number of personnel required to do a job properly. Too often a two-man task is assigned to one, particularly in smaller water systems. A one-man water works is no better than a one-pump distribution system. Adequate personnel can best be obtained by making an analysis of the work to be done and using the results to persuade governing bodies to approve the salary expenditure necessary to attract and hold the type of men needed.

Conclusion

Water works superintendents and consulting engineers are—or certainly should be—more aware of what might happen in a disaster than any one else. Consequently, they must make the responsible governing bodies equally aware of the dangers that threaten. Such a program should be carried on diplomatically but unrelentingly, both in the form of oral recommendations and as written reports for the record.

As disaster preparations frequently involve large sums of money, the selling program must also be aimed at the consumer, whose pocketbook is affected. A properly informed citizenry will buy almost any sound project, especially when it concerns as vital a matter as water supply.

Reference

1. Recommended Practice for Distribution System Records—AWWA C900. Am. Wtr. Wks. Assn., New York (1940); *Jour. AWWA,* 32:181 (Feb. 1940).

American Water Works Association

Tentative

Standard Specifications

for

CEMENT-MORTAR LINING OF WATER PIPELINES IN PLACE— SIZES 16 INCHES AND OVER

The American Water Works Assn. has adopted and promulgated these "Specifications for Cement-Mortar Lining of Water Pipelines in Place—Sizes 16 Inches and Over." These specifications are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions. The procedures outlined should be reviewed and accepted by the responsible engineer in charge of the operation before contracts are made for any such work.

Approved as "Tentative" May 27, 1954

● **Price of reprint—25¢**

● **Approximate date available—Dec. 15, 1954**

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

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Tentative Standard Specifications for

Cement-Mortar Lining of Water Pipelines in Place—Sizes 16 Inches and Over

Sec. 1—Scope

These specifications cover the requirements for the material and application of a cement-mortar lining to the inside surface of steel and cast-iron water pipelines, 16 in. and over in diameter, that have been previously installed. The application methods are: [1] cement-mortar lining of all straight pipe sections and long-radius bends by a machine which progresses uniformly through the pipe and projects cement-mortar against the pipe surfaces, obtaining a smooth lining of uniform thickness and with smooth transitions over joints; and [2] cement-mortar lining of sharp bends, specials, and areas closely adjacent to valves by handwork where machine placing is impossible.

Sec. 2—Definitions

Under these specifications, the following definitions will apply:

2.1. *Purchaser.* The word "purchaser" shall mean the person, firm, corporation, or governmental subdivision entering into a contract or agreement for the purchase of any material or any work, or both, to be performed under these specifications.

2.2. *Contractor.* The word "contractor" shall mean the person, firm, or corporation executing the contract or agreement with the purchaser to furnish any material or to perform any work, or both, under these specifications.

2.3. *Engineer.* The word "engineer" shall mean the engineer or inspector employed by the purchaser and acting as his representative; or their respective assistants, properly authorized and limited to the particular duties entrusted to them; or the purchaser himself, acting as his own engineer.

Sec. 3—General Requirements

The contractor shall furnish all labor, material, and equipment required; shall prepare all surfaces; and shall apply cement-mortar lining to the interior surfaces of the pipeline to be lined in accordance with these specifications.

Sec. 4—Supplemental Details to Be Supplied by Purchaser

Wherever these specifications are used as subsidiary specifications by the purchaser, he shall include a supplementary specific statement regarding:

4.1. *Project.* Diameter, length, and location of pipeline, including plan and profile drawings, accessible manholes, and all other details of the pipe within the scope of the contract.

4.2. *Thickness of cement-mortar lining.* Nominal thickness of cement-mortar lining required. (Table 1 is intended as a guide to the purchaser in selecting the desired thickness of cement-mortar lining.)

The purchaser should specify if the thickness of cover over rivet heads and

over lock-bar longitudinal seams of steel pipe is required to be other than $\frac{1}{8}$ in. as specified in Sec. 13.2.

4.3. *Services furnished by purchaser.* Description of all services furnished by purchaser, such as removal and replacement of line valves, operation of valves, shutting off of inflow of water from connecting pipelines, and temporary connections to consumers.

4.4. *Additional work to be performed by contractor.* Description of additional work to be performed by contractor, such as repairs to deteriorated steel pipe, excavation, backfill and resurfacing work for access holes, and opening and closing of access holes in the pipeline.

TABLE 1

Recommended Minimum Thickness of Cement-Mortar Lining for Pipelines

Type of Pipe	Diameter of Pipe *in.*	Nominal Thickness of Lining* *in.*
Cast iron	16–24	$\frac{3}{16}$
	over 24	$\frac{1}{4}$
Steel	16–36	$\frac{1}{4}$
	over 36	$\frac{3}{8}$

* For badly deteriorated pipe, the purchaser should specify such greater thickness of lining as his engineering judgment indicates.

NOTE: Work in repairing deteriorated steel pipe is sometimes included as a part of the contract for cement-mortar lining of steel pipe. Repairs on steel pipe are made before cement-mortar lining is placed. Repairs on small holes in the steel pipe are made by means of soft wood plugs driven and cut flush with the interior surface of the pipe, or by means of drilling and tapping the pipe walls and inserting screwed cast-iron or steel plugs flush with the interior surface. When repair work on deteriorated pipe is contemplated, the purchaser should include in his bid schedule, requests for a price for repairing each hole. When the repair work is more extensive than can be accomplished by the foregoing means, such repair work should be done by the purchaser at his own expense or should be performed by the contractor as required by the purchaser under the "extra work" provision of the contract.

4.5. *Water.* Supply and location of sources of water for cleaning and lining operations.

4.6. *Disposal of cleaning water.* Requirements for disposal of cleaning water.

Sec. 5—Material and Workmanship

All material furnished by the contractor must be of the quality specified. All work shall be done in a thorough and workmanlike manner by trained personnel under the supervision of experienced men skilled in the application of cement-mortar lining to pipelines in place.

Sec. 6—Equipment

The contractor's equipment for cleaning, applying cement-mortar, and curing shall be so designed and manufactured and in such condition as to permit the workmen to follow the procedure and obtain the results prescribed in these specifications.

Sec. 7—Samples of Cement-Mortar Linings

Bidders shall submit with their bids samples of cement-mortar lining, if requested by the purchaser in his supplementary specifications. Samples shall be obtained from linings made with the same type of machine and equipment and made from materials

similar to those which are to be used for cement-mortar lining under these specifications. Samples shall be large enough in area and shall be in sufficient number to indicate the surface finish, strength, solubility, and water absorption. Samples may be used by the purchaser in considering the acceptability of any bid. Samples of cement-mortar lining submitted by the successful bidder will be used by the engineer as a standard of comparison in determining the acceptability of the finished surface of cement-mortar linings.

Sec. 8—Inspection

8.1. The entire procedure of applying cement-mortar lining as herein specified shall be rigidly inspected, but inspection shall not relieve the contractor of his responsibility to furnish material and perform work in accordance with these specifications. If at any time it is found that the procedure of applying cement-mortar lining is not in accordance with these specifications, all lining so applied will be subject to rejection.

8.2. The inspector shall have free access to those parts of all plants that are concerned with the furnishing of material or the performance of work under these specifications.

8.3. The contractor shall furnish the inspector reasonable assistance, without charge, for inspection and for obtaining such information as he desires respecting the character of material used and the progress and manner of the work.

Sec. 9—Materials

9.1. *Portland cement.* Portland cement shall conform to Type II of ASTM C150 (Standard Specifications for Portland Cement), as last revised, or shall be as otherwise specified by the purchaser.

9.2. *Natural cement.* Natural cement shall conform to ASTM C10 (Standard Specifications for Natural Cement), as last revised.

9.3. *Pozzolanic material.* Pozzolanic material shall consist of siliceous or siliceous and aluminous material which, in finely divided form and in the presence of moisture, will react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Pozzolanic material shall meet the following detailed requirements, when tested in accordance with designated paragraphs of Federal Specifications SS-C-158c:

9.3.1. *Ignition loss.* Loss on ignition shall not exceed 10 per cent when tested in accordance with Paragraph 4.3.8.

9.3.2. *Fineness.* Material retained on a 325-mesh sieve shall not exceed 12 per cent, when tested in accordance with Paragraph 4.4.2.1.5.1.

9.3.3. *Compressive strength.* When 35 per cent by absolute volume of Type II Portland cement is replaced by the pozzolanic material, the 28-day compressive strength of mortar specimens fabricated with this mixture shall be at least 85 per cent of the 28-day compressive strength of specimens prepared with the straight Portland cement. Specimens shall be fabricated in accordance with Paragraph 4.4.8, with the following modifications: mix parts by weight shall be 1 part Portland cement (or mixture of pozzolanic and Portland cement), 2.75 parts of graded Ottawa sand, and sufficient water to obtain a flow of 100–115 using the method described in Paragraph 4.4.8.5. After being removed from the molds at 24 hr, the specimens shall be placed in airtight containers and stored

at 100°F for 27 days and then allowed to cool for 24 hr at 73°F ± 1.7°F before testing for strength. The average of three specimens for each mix shall be used in computation.

9.3.4. *Water requirement.* The amount of water required for cement-pozzolanic mortar to obtain a flow of 100–115, as described in Sec. 9.3.3 above, shall not exceed 115 per cent of the water required to obtain the same flow when using straight Portland cement.

9.4. *Sand.* Sand shall meet the following specifications:

9.4.1. Sand shall consist of inert granular material having hard, strong, durable, uncoated grains produced from hard crystalline rock. Sand shall be free from injurious amounts of dust, clay lumps, shale, soft or flaky particles, mica, loam, oil, and alkali. The maximum percentages by weight of deleterious substances shall not exceed the following limits:

Substance	Per Cent by Weight
Shale	1
Clay lumps	1
Mica and other deleterious substances	2
Sum of all deleterious substances	3

9.4.2. Sand shall not show a color value darker than the "reference standard color solution" prepared as required in ASTM C40 (Standard Method of Test for Organic Impurities in Sands for Concrete), as last revised. Sand shall be well graded and shall pass a 16-mesh screen.

Sec. 10—Preparation of Pipe Surfaces

The interior surfaces of pipe to be lined shall be cleaned by hand or machine, or both, and loose scale, tuberculation, loose deteriorated remains of old coating materials, and all accumulations of dirt and debris shall be removed. There shall be no sharp edges between coated and uncoated areas. Shot or sand blasting is not required to prepare surfaces of pipe for lining. Oil and grease shall be removed from interior surfaces. Accumulations of water on the bottom of the interior of the pipe shall be removed.

Sec. 11—Openings

Prior to placing the lining, openings in the pipeline leading to air valves, blowoffs, manholes, and other appurtenances, as well as the ends of pipes which transmit pressure or carry water from the pipeline, shall be temporarily covered or plugged with wooden stoppers, which shall be removed later without damaging the cement-mortar; or other suitable arrangements shall be provided. All access openings required for the lining work shall be made and closed by the contractor in the manner required by the purchaser.

Sec. 12—Mortar for Lining

12.1. Mortar for the lining shall be composed of cement, sand, and water, well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface.

12.2. The proportions of cement and sand in the mortar for the lining shall be 1 part of Portland cement to 1–1½ parts of sand by volume, the exact proportions to be determined by the characteristics of the sand used. Natural cement or pozzolanic material, unless otherwise specified by the purchaser, may be substituted for a part of the Portland cement in a proportion of no more than 1 part of natural cement or pozzolanic material to 5 parts of Portland cement by volume.

12.3. The water content shall be kept to a minimum, with allowance being made as necessary for moisture collecting on interior pipe surfaces.

12.4. Where premixed mortar is used in the lining machine, premixing shall be for a sufficient length of time, approximately 3 min, to obtain maximum plasticity, and premixed mortar shall be used before initial set has taken place.

Sec. 13—Thickness of Cement-Mortar Lining

13.1. Cement-mortar lining shall be uniform in thickness except at joints or deformation in pipelines. Cement-mortar lining thickness shall be as specified by the purchaser, and the tolerance for thickness is plus $\frac{1}{8}$ in.; no minus tolerance for thickness is allowed.

13.2. The thickness of cement-mortar lining over the top of rivet heads and lock-bar longitudinal seams of steel pipe shall be not less than $\frac{1}{8}$ in., unless otherwise specified by the purchaser.

Sec. 14—Application and Surface Finish

14.1. Immediately prior to the travel of the lining machine through the pipeline, all foreign material, including sand and loose mortar, that has accumulated since the work of preparation of surfaces was completed shall be removed.

14.2. The lining shall be applied in one course by a machine projecting the mortar against the surface of all pipe sections and long-radius bends, without injurious rebound and with sufficient velocity to cause the mortar to be densely packed and to adhere in place. The rate of travel of the machine and the rate of discharge of mortar against the wall of the pipe shall be entirely mechanically controlled so as to produce a smooth, uniform thickness of lining throughout the interior of the pipeline. The machine shall be provided with attachments for mechanically troweling the mortar, and the machine shall travel ahead of the lining so that the freshly placed and troweled mortar will not be touched until it has set. The trowel arrangement shall be such that the pressure applied to the lining will be uniform, will produce a smooth surface without spiral shoulders, and will produce a lining of uniform thickness.

14.3. Hand application of mortar at the line of rivet heads in steel pipe may be used to streamline the projection of the mortar over such rivet heads. Open joints shall be packed with mortar prior to lining, to provide a smooth surface across the joint. Such mortared areas shall be moist and unchecked prior to machine lining.

14.4. The finished surface shall be smooth and shall not have a sand finish. The finished surface of machine-placed and -troweled linings shall be tested for finish, and nine out of ten places checked shall conform to the tolerance for finished surfaces. The finished surface shall be such that if a 12-in. straightedge is laid parallel to the axis of the pipe along the surface of a straight section of machine-placed and -troweled lining, at no point will the space between the lined surface and the straightedge be greater than $\frac{1}{32}$ in. for smooth-bore pipe in good condition and $\frac{1}{16}$ in. for pipe having a rough or irregular interior. Such tolerance for surface finish, however, shall not apply where the interior surface of the pipe to be lined does not meet the foregoing conditions.

14.5. Samples of cement-mortar lining furnished by the contractor will be used by the engineer as a standard of

comparison in determining the acceptability of the finished surface of cement-mortar linings, if the purchaser requires such samples to be furnished in his supplementary specifications, in accordance with the provisions of Sec. 7 of these specifications.

14.6. Defective lining material—including, but not restricted to, sand pockets, voids, oversanded areas, blisters, drummy areas, excessively cracked areas, and unsatisfactory thin spots—shall be removed to the pipe wall, and the area shall be repaired by hand application to the full required thickness of the mortar lining.

Sec. 15—Hand Mortar Work

15.1. Cement-mortar lining of sharp bends, specials, and areas closely adjacent to valves where machine placing is impossible, together with the correcting of defective areas, shall be done by handwork. Hand-placed mortar shall have a surface which has a uniform appearance, with smooth transitions to the adjacent machine-placed lining.

15.2. Cement-mortar for handwork shall be of the same materials as the mortar for machine lining.

15.3. Areas shall be thoroughly cleaned of all loose and foreign material, and, if necessary, shall be moistened with water just prior to the placing of the mortar being applied by hand.

15.4. Steel finishing trowels shall be used for the hand application of cement-mortar, except at bends. The outer edges of hand-troweled areas may be brushed to reduce the abutting offset.

15.5. All hand finishing work in a section of the pipeline shall be completed within 24 hr after the machine application of mortar lining to that particular section of the pipeline has been completed. Machine application of mortar lining shall be slowed down or stopped, if necessary, to assure hand patching of defective machine-lined areas in accordance with this schedule.

Sec. 16—Curing

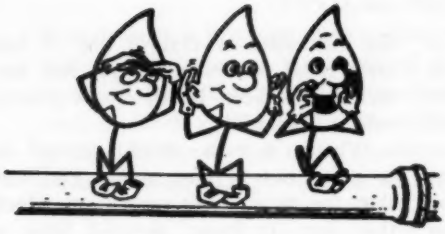
16.1. Curing operations shall begin immediately after completion of the mortar lining and hand finishing of a section of the pipeline. The pipe shall be closed, and a moist atmosphere shall be maintained in this section of the pipeline to keep the lining damp and to prevent evaporation of water from the mortar lining.

16.2. Sections of the mortar-lined pipe will be filled with water by the purchaser, unless otherwise provided, as soon as possible after lining operations, but no pressure, except that induced by variations in the grade of the pipeline, will be put on any section until the mortar lining has been in place not less than 24 hr. The contractor shall be responsible for careful curing of the mortar lining of completed sections of the pipeline until such sections are filled with water by the purchaser, or until the lining work has been accepted by the purchaser.

16.3. The exterior surfaces of pipe exposed to sunlight shall be sprinkled with water in the daytime during the lining, finishing, and curing period.

Sec. 17—Guarantee

In the event that examination of the cement-mortar lining work, made by the purchaser within a period of 1 year after final completion and acceptance of the contract work, reveals evidence of defective materials or workmanship, the purchaser may order such defective lining replaced, and the contractor shall remove and replace it at his own expense in a manner acceptable to the purchaser.



Percolation and Runoff

Soft soap about soft water seems to be foaming up all over these days, with testimonials worthy even of soft soap. Best yet has come from the West that young men still go for, who recently confided: "Soft water makes a big difference. I use only distilled water on my hair. It makes the hair easier to handle and doesn't turn blond hair dark like hard water does. It's better for the skin, too." And if you don't believe that on the authority of the *Water Conditioning Reporter* via the *Chicago Tribune* via Arlene Dahl, you can, of course, always go up and see Mae some time.

Almost equally impressive, if somewhat less likely to be noticed, is an affirmation which Ralph Shanks of St. Charles, Minn., contributed in an issue of the *REA News*. Actually the real witnesses to the wonders of soft water were completely speechless, so it was Shanks, himself, who had to report the 10-per cent increase in milk production that followed his shifting his 50-Holstein herd to softened water three years ago. Further, he was able to indicate that recent tests with 2-year-old heifers had shown a boost of 17 per cent in output. Cause to wonder, certainly, about Shanks' mare.

Much more do we wonder, though, about what this may mean to Texas. Consider, for instance, the cattle of Midland, Tex., reported by the Geological Survey to have the hardest water of more than 13,000 places it has investigated. Certainly if the moomoos of Minnesota can up their production 10 per cent on a mere reduction from 250 to 0 ppm hardness, the well-oiled bovines of Texas ought to manage at least a 50-per cent increase if their 1,250 ppm supply is so softened. And at a lactation acceleration even close to that, it shouldn't take too many softening plants to get the milk flowing freely enough to alleviate some of the worst rigors of Texas' current drought. Milk, after all, isn't too bad as a beverage, can be used in cooking, has been used for some very fascinating baths, and even makes a rather interesting mix for bourbon.

Going even beyond Midland's maximum minerality, however, the USGS notes that "many private domestic wells in the West [U.S., that is, not Mae] are yielding water in excess of 5,000 ppm hardness," the softening of which might well be expected to get production up to a point where we'd have to start worrying about involuntary milk baths, if not full-fledged floods. Then, of course, there are such surface waters as those of the Pecos River at Acme, N.M., recorded to have

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a hardness of 5,320 ppm at a flow of 13,900 cfs.; or the Little River at Sasakwa, Ohio, registering 12,700 ppm; or East Stump Lake in North Dakota, ringing up 12,300 ppm. Actually, the hardest of the natural waters are still a level higher—a little too concentrated to be useful in producing any but possibly powdered milk. Those are the natural brines, associated primarily with oil field operations, registering well over 100,000 ppm—for example, 116,000 ppm in the Dundee formation at Tuscola, Mich.

As for Mae West, time was when women rated her hardness at something higher than the 724,000 ppm theoretically possible for a water saturated with epsomite, and men . . . well! At any rate, by now even with the successful revival of one of her once most sexcessful plays, her notoriety has been boiled down practically to potability.

Which, in turn, should remind us to point out to postpotable P&Rians that the term, "soft soap," on which this item is hung, derived from a cleansing agent of the presyndet era, when water hardness really did matter.

The Water Works Management Short Course to be held Nov. 17–19 at the Univ. of Illinois will include courses in such varied subjects as the art of writing better letters, internal control and budget systems, human relations in supervision and persuasion, preparing personnel for retirement, and a work simplification program.

(*Continued on page 36 P&R*)

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(Continued from page 34 P&R)

New Jersey licenses for water supply or sewage plant operators will be available to applicants who file for examination before November 10, 1954. The Bureau of Examination and Licensing, New Jersey Dept. of Health, Trenton 7, N.J., will receive applications.

Mandatory social security coverage for self-employed professional engineers—as well as architects and accountants—was provided by a recent decision of House-Senate conferees on the Social Security expansion bill. The decision was assailed by Clarence T. Shoch, president of the National Society of Professional Engineers, who pointed out that lawyers, doctors, and other medical-dental groups were excluded. Many professionals are opposed to mandatory coverage because they do not retire at 65 and, so long as they earn more than $1,200 annually, cannot receive benefits until reaching the age of 72.

C. V. Youngquist, chief engineer of the Ohio Water Resources Board, has been appointed consultant staff director of a newly formed Cabinet Committee on Water Resources Policy. The committee is composed of the Secretary of Interior as chairman, the Secretary of Defense and the Secretary of Agriculture as full members, and the Secretary of Commerce, Secretary of Health, Education, and Welfare, and the Directory of the Bureau of the Budget participating on an ad hoc basis. The purpose is to assist the Executive Branch to consider Hoover Commission recommendations.

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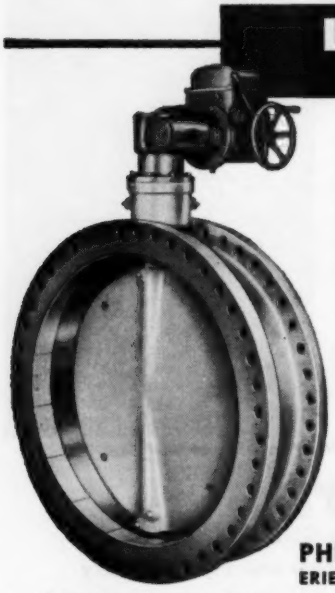

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From coast to coast, hundreds of LimiTorque Controls are in service in water works and sewage disposal plants for automatic or push-button operation of valves up to 120 inch diameter. Why is acceptance so widespread? Because LimiTorque Operators are designed to provide dependable, safe and sure valve actuation at all times.

LimiTorque is self-contained and is applicable to all makes of valves. Any available power source may be used to actuate the operator: Electricity, water, air, oil, gas, etc.

A feature of LimiTorque is the torque limit switch which controls the closing thrust on the valve stem and prevents damage to valve operating parts. Write for Catalog.

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(Continued from page 36 P&R)

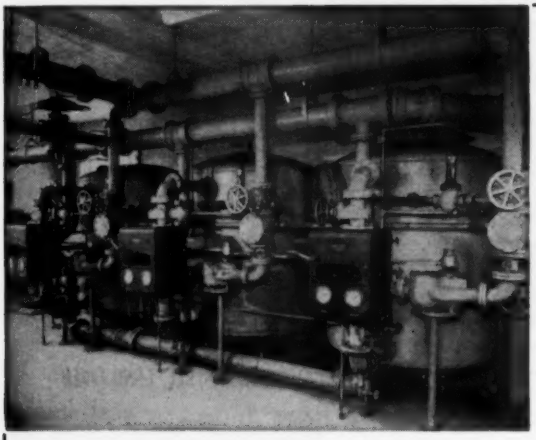
Among those winning awards from the James F. Lincoln Arc Welding Foundation for describing welding uses in nonindustrial businesses or services is our own Nelson M. Fuller, of Batavia, N.Y., who took one of the 25 Fourth Awards of $100 for his descriptions of a welded safety clamp for pipe and a cyclone separator. Another water works application which took a Fourth Award was the repair of an influent line, described by Ervin H. Hill, of the San Rafael, Calif., water and sewage plant.

The sewage men were generally more welding-conscious (or contest-conscious) than water works men, as they earned three more Fourth Awards, two Fifth Awards, and one Third Award ($250).

If the Lincoln people are still collecting suggestions on possible applications of welding, we could offer an idea of our own: How about a light-duty, low-cost welding gadget for the office or home fixit man, so he can repair that broken fan guard, file drawer, or (at home) toy truck?

Fred L. Goldsby, general sales manager of Chicago Bridge & Iron Co., has been elected a vice-president of the firm. Other personnel changes include the transfers of R. A. Johrde from Tulsa to Los Angeles, of H. B. Funderburk from Birmingham to Houston. George E. Borst has also been transferred as sales office manager from Philadelphia to New York, and Lucian J. Harris has been made manager of the Philadelphia office.

(Continued on page 40 P&R)



WATER PROBLEM?

Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

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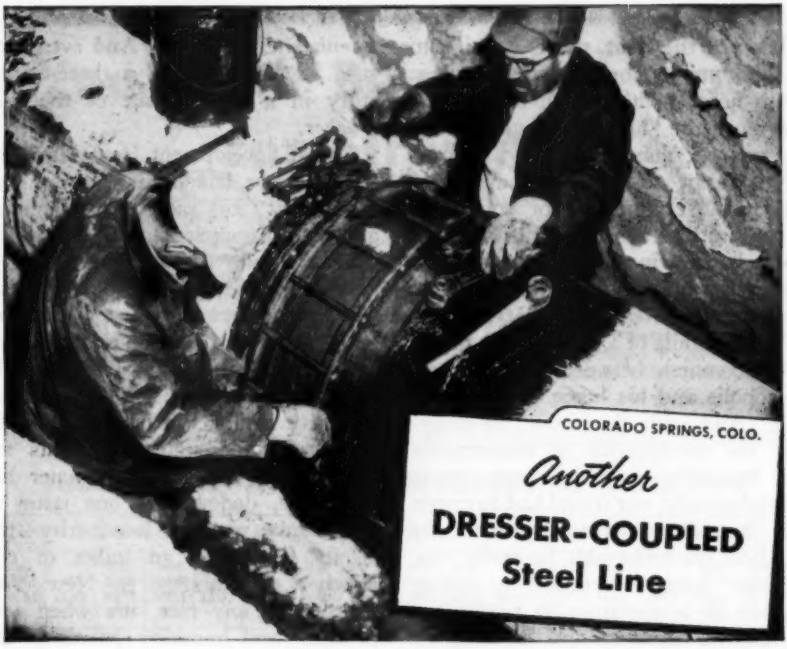

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Colorado Springs installs high pressure 30-inch line in rugged mountain terrain with minimum of heavy equipment.

High pressure steel pipe—50,000-lb. yield—was used in this line carrying water from the South Platte River to Catamount Reservoir near Divide, Colorado.

Portions of this force main were designed to operate at pressures up to 800-lb. psi. A Dresser-Coupled steel line offered engineers positive assurance of permanently tight joints.

Fast construction schedules were made and *kept* because Dresser Couplings went together quickly and easily regardless of weather or trench conditions. Laying costs were reduced by the ability of small crews to handle and join lighter weight steel pipe with a minimum of skill and heavy equipment. The absence of heat in joining prevents damage to the coal tar enamel pipe coating and lining. Glass-smooth linings assure sustained high flow-coefficients.

The result—another line that delivers, and will keep delivering water cheaper.

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DRESSER® COUPLINGS Dresser Manufacturing Division, 69 Fisher Ave., Bradford, Pa. (One of the Dresser Industries).

(Continued from page 38 P&R)

It's not the heat, nor is it going to be the humidity for very much longer. From now on, it's bound to be more and more the "humiture" upon which depends our summer comfort and efficiency, not to mention our water demand. "Humiture," of course, is something that has been with us right along, but not in that term until O. F. Hevener, an official of the National City Bank in New York City, coined it in the middle of a particularly humiturgid commute between the miasmatic metropolis and his home in Millburn, N.J. And with "humiture" to designate the combination of temperature and humidity to which man reacts physiologically, our friend had to create the "humit" to express numerically just how uncomfortable he really was, "humits" being determined by adding degrees of temperature to percentage of relative humidity and dividing by two. To make things even easier for weathermen harassed by high humiture, he combined the degree sign and the percentage sign into a special symbol, ∅, for humits.

Actually it was seventeen years ago, in September 1937, that Hevener suffered the discomfort attending the birth of his twin terms. And for twelve years following that, the twins appeared daily in the weather column of the Newark *Evening News,* the humiture readings being dropped only when the weather column was abandoned. A few other newspapers also printed the readings for a while, then discontinued them. But finally the idea caught on, first in radio and then in TV, until humiture now looks like a sure thing for immortality. Sure enough, in fact, to be listed in the Funk & Wagnalls *New International Year Book for 1951* and to be included on the "almost" list of the *Thorndike-Barnhart Dictionary.* And even more sure for having rated a three-column story in a recent issue of the *New Yorker.*

Latest development from Hevener's headquarters has been a triple-threat instrument for measuring humiture along with temperature and humidity, thus obviating the addition and division otherwise required to determine whether current humiture is an ideal 60∅, a distinctly uncomfortable 75∅, or a completely prostrating 90∅. By including the basic temperature and humidity readings in his device, which is now in the state of patents and manufacturers pending, Hevener has, of course, dodged the one issue we would take with his humiturity—that is, its failure as an index of cold weather discomfort. In New York winters, at any rate, it's when temperature and humidity go off in different directions that the discomfort is greatest—the 60∅ resulting from a temperature of 30°F and a humidity of 90% being chillingly different from the ideal combination of 70°F and 50%. Perhaps this would indicate the wisdom of ignoring humiture when temperatures fall below 50°F. On the other hand, perhaps the difficulty could be solved by redefining "humits" so that below 50°F they would be determined by adding percentage humidity to the difference between temperature and 100°F and dividing by 2. On that basis, the 30°F-90% example above would result in a decidedly uncomfortable 80∅—a lot more indicative of how New York really feels under those circumstances.

To the water works field, of course, these cold-weather deficiencies are rather beside the point, for it is primarily as an indicator of summer water demand—for drinking, bathing, air

(Continued on page 42 P&R)

You Can't Beat Steel Pipe for Strength

Bethlehem Tar-Enameled Steel Pipe is widely used for water and sewage service because of its resilience, resistance to shock and corrosion, and leak-proof joints. But the most important reason for its popularity is its great strength, which is evident in the chart below.

The chart shows the theoretical working and bursting pressures for various pipe diameters and thicknesses. The pressures shown are based upon the use of steel conforming to ASTM Specification A-283, Grade B, having a minimum ultimate tensile strength of 50,000 psi. When exceptionally severe internal working pressures are encountered, the use of higher strength steel is recommended for greater economy. The nearest Bethlehem office will be pleased to supply complete information.

THEORETICAL INTERNAL PRESSURES OF STEEL PIPE

	1/4 in.			5/16 in.			3/8 in.			7/16 in.			1/2 in.		
INSIDE DIAM IN.	WT LB/FT	MAX WRK PRESS PSI	MIN BURST PRESS PSI	WT LB/FT	MAX WRK PRESS PSI	MIN BURST PRESS PSI	WT LB/FT	MAX WRK PRESS PSI	MIN BURST PRESS PSI	WT LB/FT	MAX WRK PRESS PSI	MIN BURST PRESS PSI	WT LB/FT	MAX WRK PRESS PSI	MIN BURST PRESS PSI
18	49	445	1390	61	555	1735	73	665	2080	85	775	2430	96	890	2780
20	54	400	1250	68	500	1560	81	600	1875	94	700	2180	107	800	2500
22	63	365	1135	78	465	1420	93	550	1700	109	640	1985	124	730	2270
24	69	335	1040	86	420	1300	102	505	1560	119	585	1820	136	665	2080
30	86	270	835	108	340	1040	129	405	1250	150	475	1455	170	535	1670
36	106	225	695	130	280	870	155	340	1040	181	395	1210	206	445	1390
42	119	195	595	148	240	745	177	285	890	206	335	1040	234	380	1190
48	137	170	520	171	210	650	203	250	780	236	290	910	268	330	1040
54				192	190	580	230	225	695	267	260	810	303	295	925
60				214	170	525	255	200	625	296	235	730	336	265	835
72							309	170	520	359	195	605	408	220	695
84							357	145	450	412	170	520	470	190	595
96	The recommended minimum wall thickness is approximately the pipe diameter divided by 165. Pipe having this diameter-thickness ratio, when backfilled and properly tamped, will withstand any depth of cover. For buried pipe, the recommended minimum thicknesses are shown immediately above heavy black line.									470	145	455	539	165	520
108													*611	150	465
120													*669	135	415

*Under certain conditions stiffeners may be required to reduce deflections.

$$P = \frac{t \times Ts}{r}$$

P = internal pressure, psi
t = thickness, in.
Ts = allowable unit stress = 60% x 27,000 (yield point) = 16,000 psi
r = radius of pipe, in.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

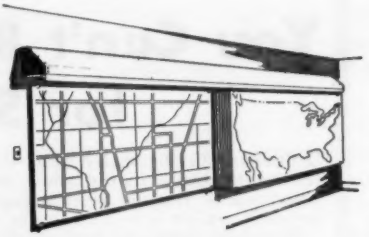
BETHLEHEM STEEL

BETHLEHEM *Tar-Enameled* STEEL PIPE

(Continued from page 40 P&R)

conditioning—that humiture could be useful. Certainly the cold weather comforts of water are not much more significant than the quantity of water used in steam or in hot-water heating systems. Besides, now in the midst of the hay fever sneason, it's the hot kind of humiture, internal as well as external, that has us demanding a different kind of refinement of the Hevener concept—the "humiten," that is—a unit which includes the pollen count in addition to temperature and humidity, thereby to establish a really comprehensive index of discomfort.

A new sedimentation basin for conventional water treatment has been produced by Graver Water Conditioning Co. The basin utilizes a Roto-Rake sludge scraper.



A rack to be used for both the display and storage of large maps and drawings is being marketed by Roll-A-Way Filing Systems Co., 4845 Bellevue Ave., Detroit 7, Mich. The maps are arranged on parallel tracks, much like sliding doors, and may be either wall mounted or mounted on caster-equipped standards for portability. The wall-mounted model (above) is fluorescent lighted.

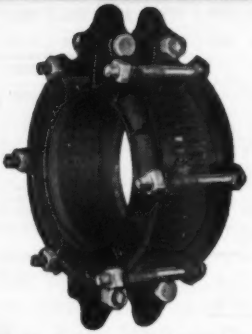
(Continued on page 44 P&R)

BELCO

An organization of engineers engaged in the design, development and fabrication of equipment for "Removal of Water Impurities". Belco technicians, chemists and electronic control specialists have designed and furnished water treating installations ranking from the smallest to the largest in the world. For a discussion or analysis of your problems call a Belco man.

Belco
INDUSTRIAL EQUIPMENT DIVISION, INC.
PATERSON 3, NEW JERSEY

FOR REPAIRING BROKEN MAINS



Skinner Seal Split Coupling Clamp. One man can install in 5 to 15 minutes. Gasket sealed by Monel band. Tested to 800 lbs. line pressure. A lasting repair. 2"-24" inclusive. Write today for new catalog.

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA, U.S.A.

When pipe efficiency drops you need... **National**

When pumping costs rise, pressures fall and capacity is way down—
You need *National* cleaning!

Often, lines assumed to be in top operating condition are actually delivering less than half of their rated capacity. For instance—a tuberculated 48" pipe, having a co-efficient of 93 can carry no more water than a clean 42" pipe. Think how much difference this makes in costs when it must be compensated for by either greater power consumption at the pumping station or by larger mains in the ground.

Remember, the National Water Main Cleaning Company *guarantees* to restore any water main to 95% of its original carrying capacity.

There's no obligation when National's engineers inspect and estimate cleaning costs of your mains, so write or phone today!

NATIONAL WATER MAIN CLEANING COMPANY
50 Church Street • New York, N.Y.

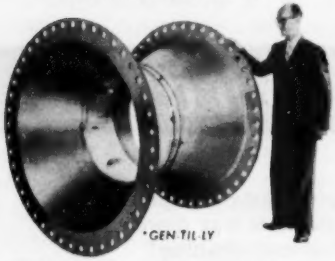
37

ATLANTA, GA; 333 Candler Building • BERKELEY, CALIF; 905 Grayson Street • DECATUR, GA; P. O. Box 385 • BOSTON, MASS; 115 Peterboro Street • CHICAGO; 122 So. Michigan Avenue • ERIE, PA; 439 E. 6th Street • FLANDREAU, S.D; 315 N. Crescent Street • KANSAS CITY, MO; 406 Merchandise Mart and 2201 Grand Avenue • LITTLE FALLS, N.J; BOX 91 • LOS ANGELES; 5075 Santa Fe Avenue • MINNEAPOLIS, MINN; 200 Lumber Exchange Building • RICHMOND, VA; 210 E. Franklin Street • SALT LAKE CITY; 149-151 W. Second South Street • SIGNAL MOUNTAIN, TENNESSEE; 204 Slayton Street • MONTREAL, CANADA; 2032 Union Avenue • WINNIPEG, CANADA; 576 Wall Street • HAVANA, CUBA; Lawrence H. Daniels, P. O. Box 531 • SAN JUAN, PUERTO RICO; Luis F. Carat ni, Apartado 2184.

it's REVERSIBLE

The Gentile* FLOW TUBE

measures flow in either direction



*GEN TIL LY

REVERSIBLE . . . The Flow Tube is symmetrical, with upstream and downstream ports identical. When the flow is reversed, the differential is reversed. Permits metering reverse flow at lowest possible equipment cost.

LOW INSTALLED COST . . . Average length is only 1½ times the pipe diameter, and straight runs entering and following are not required unless installed near throttling valves or regulators.

ACCURACY . . . Produces differential from points of equal cross-sectional area . . . furnished with head capacity curves, and guaranteed for exceptional accuracy when used with any standard indicating, recording or integrating meter.

LOWEST HEAD LOSS . . . The Flow Tube can be designed to produce a measurable differential with the lowest permanent pressure loss of *any* type head meter.

Write for Bulletin FT-101, or for specific recommendations.

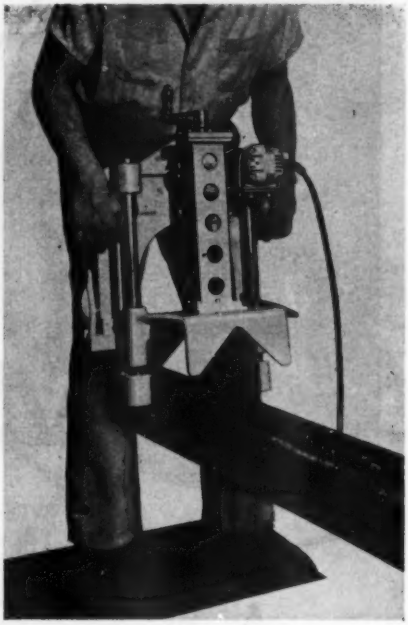
1870 1945 75 YEARS OF EXPERIENCE

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE UNION, N. J.

AUTOMATIC VALVES
SAFETY VALVES FLOW TUBES

(Continued from page 42 P&R)



A portable power saw for rapid field cutting of 2- to 8-in. cast-iron or steel pipe has been produced by E. H. Wachs Co., 1525 N. Dayton St., Chicago 22, Ill. The "guillotine" design (above) permits operation in a space only 25 in. wide, while the chain pipe vise and machined saddle base permit obtaining a true right angle cut. Cutting time for 6-in. pipe is said to be 8 min for steel; 4 min for cast iron.

Donald P. Schiesswohl, formerly sanitary engineer with the Florida Board of Health, has joined the headquarters staff of the Federation of Sewage & Industrial Wastes Assns. as executive assistant. His responsibilities in the newly created post will include assisting executive secretary-editor W. H. Wisely at Champaign, Ill., and acting as assistant editor of *Sewage & Industrial Wastes.*

(Continued on page 46 P&R)

In England with CENTRILINE

Here is another example of the growing, world-wide acceptance of the Centriline Process! In Manchester, England, a total of over 23,000 feet of 48″, 90″ and 99″ *new* steel pipe is currently under contract to be centrifugally lined with cement mortar. Centriline in conjunction with John Mowlem & Co., Ltd., London, is handling the entire project for the Manchester Corporation Water Works.

On this project, brand new steel pipe is being Centrilined to guarantee indefinite pipe life. But Centriline is just as effective on old pipe . . . tuberculation and corrosion are eliminated forever . . . small holes are sealed . . . flow capacity is increased, pumping costs lowered . . . and the pipe is given a complete new lease on life. Follow the lead of water works officials around the world by turning to Centriline for the solution to *your* pipe problems.

3,500,000 FEET OF EXPERIENCE

CEMENT-MORTAR LINING OF PIPES IN PLACE

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

140 CEDAR STREET • NEW YORK 6, N.Y.

Branch Offices in Principal Cities of the United States and Abroad

(Continued from page 44 P&R)

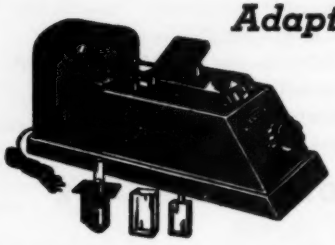
A small-diameter pipe foundry has just been constructed by McWane Cast Iron Pipe Co. of Birmingham, Ala., which is beginning to produce 2-in. and 2¼-in. centrifugally cast pipe in 18-ft lengths (above). Pipe is available either in bell-and-spigot form or with Boltite mechanical joints. Each length of pipe has a tapping collar behind the bell and cast integrally with it.

Dirt cheap has always been considered mighty expensive compared to the price of public water supply, and now with even the cheapest dirt running to at least $10 per 1,000 cu ft, that point ought to be settled for once and all. Settlement came from Nassau County, N.Y., where advertising the job of digging and removing 50,000 cu yd of earth to form a basin near Levittown brought bids ranging from $13,975 down to one cent. The low bidder was a construction company that wanted the dirt for fill on its projects; the high bidder was obviously 1,397,500 times less interested in it. But presuming that the high bidder didn't want the dirt at all, $13,974.99 can be set as the cost of "distribution," which figures out to more than $10 per 1,000 cu ft. What price water, indeed?

(Continued on page 80 P&R)

KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

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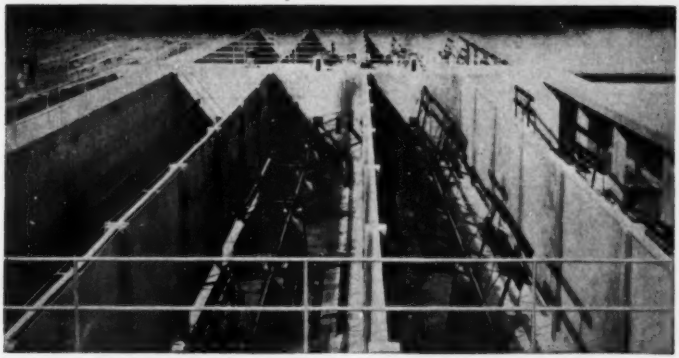
to meet your exact water treatment needs



RAPID MIX—HOMOMIX
Accomplishes instantaneous, violent, uniform blending of a liquid and one or more chemicals without the use of a mixing tank.
Send for Technical Supplement HM.

FERROFILTER
Backwashable ventilated anthracite contact bed for iron and carbon dioxide removal.
Send for Bulletin 252B.

FLOCSETTLER
For turbidity removal and softening; combines all modern concepts of water treatment into one unit.
Send for Technical Supplement FL.

COLLECTORS
Sturdily constructed sludge removal mechanisms for both rectangular or circular tanks.
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PUMPS
Complete line of split case, end suction, axial flow, deep well turbine, and sludge pumps.
Send for Bulletins.

FLOCCULATION EQUIPMENT

The "AMERICAN" Paddle Flocculation Unit has been particularly designed to efficiently carry out the slow mixing and flocculation functions required in the coagulation process. In addition, inherent design features have been utilized which allow for flexibility in operation, ease of installation, and simplified maintenance.

A choice of units is available which allows for adaptations to existing basins. Vertical paddle units in two basic styles can be utilized for smaller tanks, with horizontal multiple assemblies for the larger tanks.

The "AMERICAN" design is uniqne in that the central shaft may be either solid or a hollow torque tube with a stub shaft member (*always being of solid machined shafting*) through the bearings and stuffing boxes. The solid stub shafts and central shaft members are connected by means of rigid, flanged type couplings in a manner which facilitates installation and removal of each paddle unit. This construction has a distinct advantage over other types of construction because it eliminates the necessity for machining down the main torque tube and thereby decreasing both the strength and life of the shafting. **Send for Technical Supplement PF.**

**IN OUR 86TH YEAR*

AMERICAN WELL WORKS

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112 North Broadway
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Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH • ENGINEERING • MANUFACTURING

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The test of a century

F.P.G.

This is Lancaster, Pa., County seat in one of the most highly cultivated farming districts in America.

Bettmann Archive

Old print showing southwest view of Lancaster about 100 years ago.

MODERNIZED **cast iron**

is the test that tells!

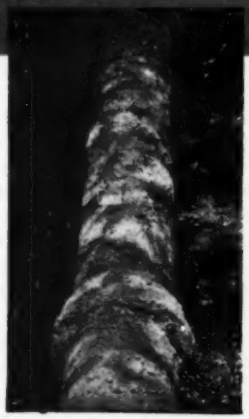
LANCASTER installed cast iron water mains 100 years ago . . . and installs them today.

Lancaster, Pa., has grown in 100 years from about 12,000 population to nearly 65,000 — but it has not outgrown the habit of buying cast iron pipe. From four miles of water mains a century ago, the present distribution system has increased to 105 miles of pipe—all of it cast iron pipe. Services have grown from 2,000 to nearly 20,000.

The word "test" means—"*put to the proof*"—according to the dictionary. Well, 60 utilities have put cast iron pipe to the *proof* for a century—a test to end all tests. They installed cast iron water or gas mains 100 years, or more, ago that are still in service. Yes, the test of a century has *proved* beyond question the long life and low cost per service year of cast iron pipe.

Cast iron pipe has been a rugged, long-lived product from the earliest days. Today's *modernized* cast iron pipe, centrifugally cast, is even stronger, tougher, and more uniform in quality. And, where needed and specified, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout the long life of the pipe.

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.



This cast iron water main laid in 1835 by the Bureau of Water of Lancaster is still functioning after 119 years of service.

CAST Q IRON

The Q-Check stenciled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe FOR MODERN WATER WORKS OPERATION

The Reading Meter

Flood Control Politics: *The Connecticut River Valley problem, 1927–1950. William Edward Leuchtenburg. Harvard Univ. Press, Cambridge, Mass. (1953) 339 pp.; $5*

So much has been said and written about the evils of centralized planning and federal control of water resources that the casual reader may be forgiven for forgetting not merely the arguments in the other direction, but the fact that there are such arguments. Mr. Leuchtenburg is no rabid partisan of federal control—in fact his criticism of wavering, muddling-through, and the rule of expediency in Washington is withering—but he turns a historian's eye on the astonishing history of state and regional approaches to "control" of the Connecticut River, and scores them as a complete failure. Notes and bibliography occupying nearly a fifth of the book buttress the author's argument that state and interstate action in New England was reluctant, ineffective, and tended only to magnify normal conflicts of interest into conflicts between states. The book constitutes a sober reminder that, whatever the flaws in the federal approach, it still contains virtues which are not lightly to be discarded.

Water Laws in Moslem Countries. *Dante A. Caponera. FAO Development Paper 43 (Agriculture), Food & Agriculture Organization of the UN, Rome, Italy (1954) 202 pp.; paperbound; $2.00 from Columbia Univ. Press, 2960 Broadway, New York 27, N.Y.*

As might be expected of the theology and government of extremely arid lands, water is of prime importance and has received considerable attention. The Prophet Mohammed was directly responsible for the tradition that "no one can refuse surplus water without sinning against Allah and against man," and he prohibited its sale for that reason. However, this initial rule was unquestionably intended for the primitive community of Islam's earliest days, and the need to adapt it to different social structures has resulted in considerable interpretation. The fact that the Moslem world is divided into at least a dozen sects further complicates the matter. In addition to a survey of religious and cultural factors bearing on the control of water rights, a country-by-country survey has been made of recognized judicial traditions and modern legislation.

Inventory of Published and Unpublished Chemical Analyses of Surface Waters in Eastern United States. *Notes on Hydrologic Activities, Bul. 6, Subcommittee on Hydrology, Federal Inter-Agency River Basin Committee (1954) 97 pp.; paperbound; 50¢ from Government Printing Office, Washington 25, D. C.*

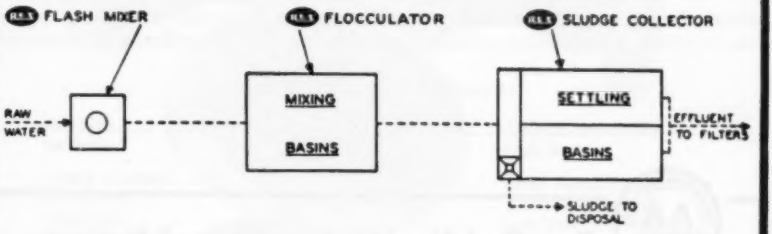
An even dozen federal agencies, with the Geological Survey acting as publishing coordinator, have cooperated to prepare this bibliography of analyses, both published and unpublished, of surface waters. This report covers the region roughly east of the Mississippi, and gives detailed information on the type of information available. Location of sampling points, period of record, number and type of analyses, are all given. For the actual analyses, of course, the basic references would have to be consulted.

(*Continued on page 52 P&R*)

we treat them all like...

finger prints!

FOR WATER TREATMENT



Just as no two sets of finger prints are ever alike, so, too, are all water-treatment problems *different.* Velocities, head loss, capacities, site conditions, tank or channel hydraulics, and many other factors vary from plant to plant. That is why we at Chain Belt have no standard answer to a treatment problem. We study each application carefully, and from our broad background of experience recommend the type and size of equipment you need for most efficient, economical results. The flexibility of Chain Belt Water Treatment equipment is sure to provide an answer to your particular problem.

So, check with Chain Belt Company before you select and specify equipment. Ask your nearest Rex Sales Engineer to work with you to assure the results you want, or write direct to Chain Belt Company, 4609 W. Greenfield Ave., Milwaukee 1, Wis.

CHAIN BELT COMPANY

District Sales Offices and Distributors in all principal cities

The Reading Meter

(Continued from page 50 P&R)

Guide to Community Action: *A sourcebook for citizen volunteers. Mark S. Matthews. Harper & Bros., New York (1954) 434 pp.; $4.00*

This book makes its appeal to the volunteer workers in community service organizations, but it is perhaps as necessary to the municipal official who needs to understand such citizen groups and how to work with them. There are still too many public officials who react with hostility to citizen interest in their functions and departments. Not only does such an attitude result in ill will that can be disastrous politically, but it also misses golden opportunities to enlist community support for needed projects or appropriations. Even if the water utility has no axe to grind, a responsive attitude to groups who are interested in the relation of the water supply to fire protection—or community growth, or fluoridation, or industrial expansion, or whatever—will earn dividends in public relations. The lasting good will of those groups that are struggling to find their way might also be earned by a tactful recommendation of this invaluable source book.

Municipal Officials Manual. *Texas Construction Council (1954) 27 pp.; paperbound; $1.50 from Municipal Contractors Assn.—AGC, 610 Thomas Bldg., Dallas, Tex.*

Intended as a guide to procedure in financing and executing municipal construction programs in Texas, this question-and-answer bulletin is endorsed by

(Continued on page 54 P&R)

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For Public Water Fluoridation

Sodium Silicofluoride—98%

(Dense Powder)

Sodium Fluoride—98%

(Dense Powder or Granular)

Meets AWWA specifications

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Available Immediately
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24 inch.
TRINITY VALLEY IRON AND STEEL CO.
Phone PErshing 3141
Fort Worth, Texas
P. O. Box 864

The Reading Meter

(Continued from page 52 P&R)

the League of Texas Municipalities, the Texas Society of Professional Engineers, the Texas Society of Architects, and the Municipal Contractors Assn.—AGC. The information presented is clear and helpful, but has specific application to Texas, rather than being general.

Proceedings of the 17th Annual Short Course for Water and Sewerage Plant Superintendents and Operators. 1954. *Bul. 44, Engineering Experiment Sta., Louisiana State Univ. and Agricultural & Mechanical College, Baton Rouge 3, La. (1954) 160 pp.; paperbound; $1*

Includes discussions on plant arithmetic, main disinfection, membrane filters, water treatment chemistry, tastes and odors, filter operation and maintenance, clarifiers, dosing siphons, automatic computers, chlorine, tank and equipment maintenance, and certification and licensing.

Work Injuries in the United States During 1952. *Bul. 1164, US Dept. of Labor (1954) 41 pp.; paperbound; 30¢ from Government Printing Office, Washington 25, D.C.*

This compilation contains basic work-injury data for industry self-appraisal. It is to be hoped that editions for succeeding years will improve in statistical significance as more water utilities report their experiences. A prayer should be added that this may be done without reversing the improvement in injury-frequency rates shown in this report.

We were losing revenue 'til we metered with accurate AMERICAN METERS
American Meter accuracy means full revenue from metered water in your system. Too, simplicity and interchangeability of all parts keeps your costs rock-bottom.
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CARRIZO SPRINGS, TEXAS

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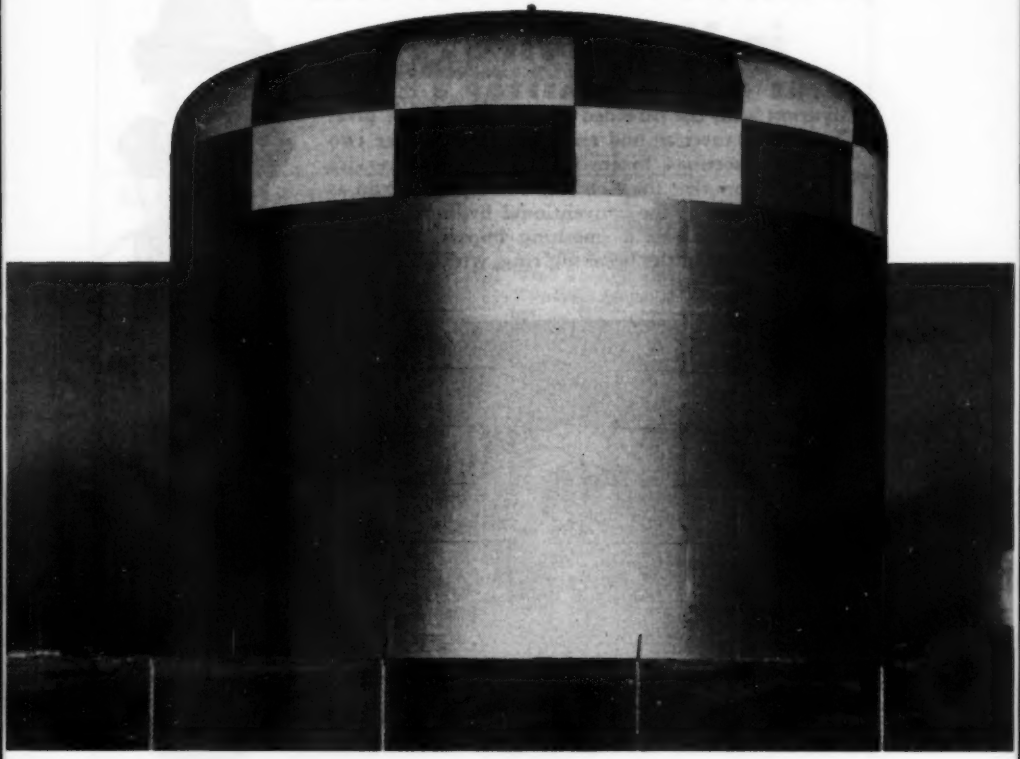
(CAPACITY 7,268,000 GALLONS)

for South Pittsburgh Water Company



by PITTSBURGH • DES MOINES

This huge water storage unit evidences typical Pittsburgh-Des Moines fine workmanship in shop fabrication and field erection. Measuring 116 feet in diameter, with a water depth of 95 feet and total capacity of 7,268,000 gallons, the South Pittsburgh Water Company giant is the largest standpipe-type storage tank built in America to date. • Let us quote on your water storage needs.

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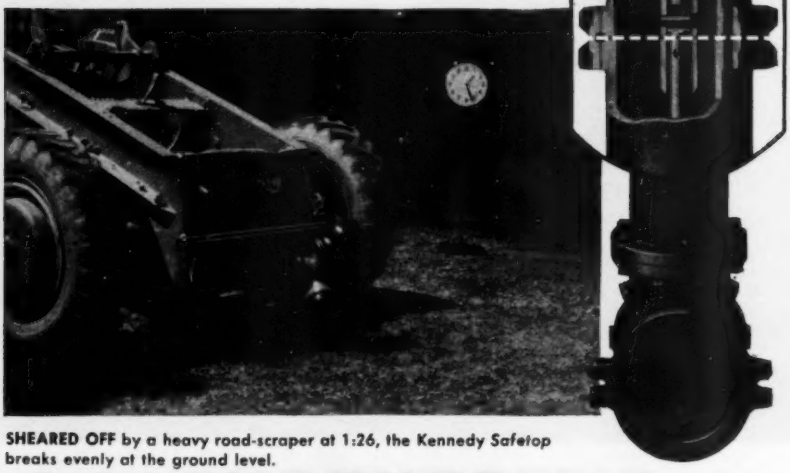
From Break to Service *in 11 minutes . . .*

• **THE KENNEDY SAFETOP** is the only hydrant with the threaded breaking ring that gives positive connection and rigid alignment of the two standpipe sections. Extensive tests and actual service reports show that the Kennedy *Safetop* can stand as tough a blow as the conventional hydrant without damage. But under a smashing impact, it always breaks cleanly at the breaking ring, without damage to working parts.



SHEARED OFF by a heavy road-scraper at 1:26, the Kennedy *Safetop* breaks evenly at the ground level.

Photos taken at N. Y. State Section meeting, A.W.W.A., April 1949.

WITH ONLY an inexpensive *Safetop* Repair Kit and a few common tools, one man can permanently repair the Kennedy *Safetop*.

NO NEED FOR DIGGING because breakage is all above ground . . . no flooding because compression-type valve closes with water pressure.

IN JUST 11 MINUTES the Kennedy *Safetop* is back in service . . . working as smoothly and efficiently as if nothing had happened.

WRITE FOR SAFETOP BULLETIN 105

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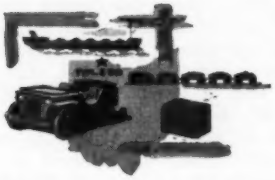

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

LABORATORY METHODS AND APPARATUS

Amperometric Techniques for Chlorine Residual. G. C. CLARK. Instruments and Automation, 27:610 ('54). Free and combined Cl in water are measured separately by amperometric titration with phenylarsene oxide (I) in Pt-Ag cell. Concn. of I is preferably such that measurement is read directly in ppm. Free Cl is detd. directly at pH 7, whereas Cl combined as monochloramine (II) is detd. as I, titrated as for Cl, after being released from KI by II at pH 7. Cl combined as dichloramine is detd. as for II, but at pH 4 . Refinement using Pt alloy–Cu cell with coaxial electrodes and recording microammeter produces continuous record of free residual Cl in water lines.—*CA*

Rapid Method for Distilling Fluorides From Water Samples. R. E. FRAZIER & H. G. OLDFIELD. Pub. Health Rpts., 68:729 ('53). Flask is charged with 15 ml of H_2SO_4; glass beads, small amt. of $AgSO_4$, and sufficient water to give boiling point of 138°–140° are added. In making distn., sample is introduced at rate sufficient to maintain temp. of 138°–140° with heating unit set at full capacity. Distn. proceeds at rate of approx. 7 ml/min. At end of one distn., excess sample in separatory funnel is discarded and new sample introduced, lead-in tube to flask being removed and flushed with new sample. Separatory funnel and lead-in tube are again placed in position, and distn. is restarted. Acid charge in flask can be used repeatedly. Frequency of acid renewal depends upon mineral and org.-matter content of water analyzed. As many as 20 distns. have been made from one batch of acid. Distn. app. consists of 500-ml 3-necked flask fitted with thermometer extending into liquid being distd. Sample lead-in tube is 0.1-ml pipet connected to separatory funnel by rubber tubing and fitted into one neck of flask by means of rubber sleeve. All other joints are standard taper glass. Separatory funnel has notched stopcock for easy control of flow at low rates; glass tube fitted in rubber stopper reaches nearly to bottom of funnel to provide const. head of liquid. 750-w heater with transformer control is used. Above method requires less than 30 min and appears to be sufficiently accurate for routine work. Equil. studies have shown that at distn. rate of 7 ml/min at 138°–140°, distn. of 50 ml to waste at beginning of each new sample is sufficient. Addn. of Al and of dissolved Si to test samples does not appear to offset significantly recovery of fluoride from distillate.—*CA*

A Double Syringe-Pipet for Dissolved-Oxygen Estimations. H. BARNES. Analyst (Br.), 78:501 ('53). Simple pipet, constructed from 2 hypodermic syringes, has been devised to deliver simultaneously manganous sulfate solution and mixture of potassium iodide and potassium hydroxide solutions in amounts required for Winkler determination of DO. Greater accuracy was obtained in analysis of sea water when using apparatus at sea than by standard technique. —*WPA*

Dissolved-Oxygen Measurement. A. T. IPPEN & C. E. CARVER JR. Instruments and Automation, 27:128 ('54). This work on dissolving O from air, done in connection with US Public Health Service, to be used in activated sludge process for treating sewage and industrial waste. Dropping Hg and rotating Pt electrode methods were used. Diagram of each app. is shown, operating characteristics are discussed, and results plotted on 4 graphs. Dropping Hg electrode should prove valuable where rapid detn. or control of DO is important, but it has handicaps. Advantages of rotating Pt electrode are: rising air bubbles do not interfere, disturbances do not affect it, rec-

(Continued on page 66)

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(Continued from page 64)

ords are continuous straight lines, and it is less bulky, stronger, and more easily operated and maintained.—*CA*

Some Aspects of the Design and Operation of Vertical Laboratory Autoclaves. C. C. THIEL, H. J. BURTON & J. MCCLEMONT. Proc. Soc. Applied Bact. (Br.), 15:53 (Apr. '52). High reproducibility of process of sterilizing bact. media in lab. autoclaves desirable. Sterility more certain and growth-promoting abilities of media more uniform. Wide differences between plate counts when media batches divided and treated at 121° for 15 min and 126° for 45 min illustrated. In 18″-diam. vertical autoclaves suggested, given sterilizing process ought to be controlled to accuracy of ±1 min and ±1°. This implies variability in bactericidal effect (for holding time of 15 min and sterilizing temp. of 121°) of the order of ±25% based on Q_{10} of 8. Heating and cooling times above 100° may conveniently be restricted to 10 min each when total sterilizing effect due to these parts of process equivalent to 3 min at 121°. For small vols. of liq. or solid media in test tubes or medical flats, time-temp. curves of media approximated closely those of internal atmosphere of autoclave, but only if former air free. Complete expulsion of air most difficult with loads consisting entirely of tubed media. Hg thermometer in or near vent best practical way to det. when exhaust steam air free. Further 3-min delay in closing vent elims. air pockets. Thermometer recommended to measure sterilizing temp. Heat penetration into large vols. of media studied to det. holding times needed to give sterilizing effect equiv. to that in small vessels. Full details of satisfactory gas burning and control equip. given. Series of suitable performance tests given and ref. to automatic timers made.—*R. E. Noble*

Application of Molecular Filter Membranes to the Analysis of Aerosols. A. GOETZ. Am. J. Pub. Health, 43:150 ('53). Molecular filter membranes (MF) have recently been found very useful in bacteriological examination of water. Further research has indicated that MF will have even greater utility in analysis of aerosols. Prior to World War II MF stable only as partially or entirely hydrated gels, and production was difficult. Results were not always predictable. Research at California Institute of Technology has led to production of membranes that are very nearly "wet-dry" stable and possess flow resistivity which will permit aerosol filtration at sampling rates comparable to those for fibrous materials, such as paper filters, designed for similar purpose. Aerosol assay (AA types) of MF consist of stabilized, dry, cellulose-ester-gel membranes (120–160 μ thick) up to 8 sq ft in area, entirely devoid of fibrous structure, of uniform high porosity (80–85%), dimensionally stable in wet and dry state within 1%, and of sufficient permeability to act as aerosol filters. Pore size and uniformity can be controlled within narrow limits by varying production process. MF stable in presence of saturated aliphatic and aromatic compounds and water. Alcohols and ethers bring about structural deformation. MF soluble in methyl alcohol, ketones, and esters. Water-extractable substance makes up less than 1% of membranes, and ash content is barely traceable. Thermoplastic is formed at temperature above 65°C, decomposition and melting occur at temperatures above 125°C. Membranes are inflammable. MF adaptable to photoelectric and radioactivity measurements, microscopic examination, microcinematography, and electron microscopy. May be modified for use in analysis of fumes, smokes, and microbiological aerosols. At present more experimentation is warranted in study of smokes if mechanism of filtering process is to be fully understood. In analysis of microbiological aerosols, MF has many potential uses and exhaustive studies of its performance seem warranted. This article presents many technical details on assembly of apparatus, flow rates, and filtering efficiencies.—*PHEA*

Monitoring of Water for Fission Product Contamination. W. R. LOOSEMORE. Nucleonics, 11:36 (Oct. '53). Low-voltage G-M counter of liquid-annulus type has been designed to monitor water contaminated with fission products in range 5×10^{-4} to 0.5 $\mu\mu$c/ml if sample is diluted to maximum of 10 times its original volume. Meter scale is roughly logarithmic, allowing measurements over range of 0.1–10 mr/hr. Construction and characteristics of counter are described. Simple circular calculator was devised, having 3 concentric discs and cursor. Time after burst and dilution factors, as well

(Continued on page 68)

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(Continued from page 66)

as indicated meter reading, are taken into account in calculator. Calibration of counter employs jig incorporating radium-impregnated sintered silver source. Operating pointers are listed.—*PHEA*

A New Apparatus for the Collection of Bottom Plankton. J. WICKSTEAD. J. Marine Biol. Assn. United Kingdom, **32**:347 ('53). Illustrated description is given of apparatus for sampling plankton in immediate vicinity of sea bottom. Apparatus consists of net supported on rectangular base and mounted on metal runners to raise it about 8″ from ground. At front end of net is metal box with hinged door and at other end of net is small bucket to hold catch. Door is locked in place while net is being shot; when net reaches bottom, locking mechanism is released and pressure of water as net is towed along bottom is sufficient to open door. Door will remain open at speeds of towing of about 35 fpm. When towing stops, door again shuts and locks while apparatus is being hauled in. Small coarse-silk net can be attached to rear of metal base, to catch smaller benthic fauna which are disturbed during tow.—*WPA*

A Recording Bathypitotmeter. W. V. R. MALKUS. J. Marine Research, **12**:51 ('53). Apparatus is described and illustrated for recording velocity of current, temperature, and pressure at various depths in sea, so that vertical profile of ocean current may be determined in 1 hr. Instrument is lowered on standard hydrographic wire and uses sensors which make recordings on waxpaper roll. —*WPA*

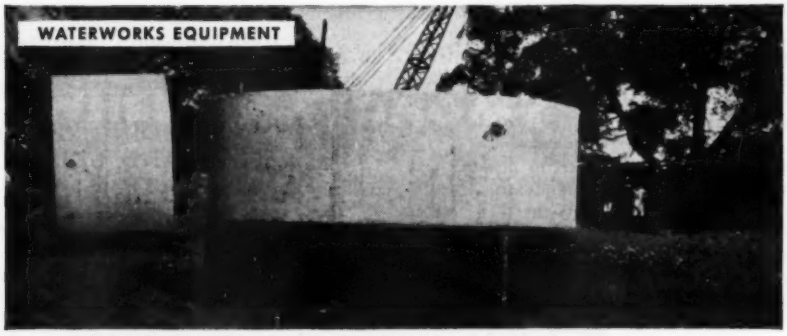
The Densigraph. E. FØYN. Fiskeridirektorat. Skr. Havundersok. (Norweg.), **10**: No. 5 ('53). Description is given of apparatus, known as densigraph, for continuous determination of density of sea water. Apparatus consists of 3 vertical tubes with ID of about 0.5 cm, communicating with one another through common horizontal tube at base. Middle tube, which is shortest, is about 100 cm long. One outer tube is about 5 cm longer and opens out at top into small funnel. Third tube, which is longest, has arm at top, inclined at angle of about 15 deg to horizontal. Water flows continuously into funneled tube and out through middle tube. Immiscible liquid, such as gasoline colored with Sudan red, is placed in longest tube to balance system and reaches into oblique arm of tube. Variations in density of water in other tubes cause alterations in level of gasoline in oblique tube and these can be recorded photographically. In appendix, brief description is given of preliminary laboratory experiments on use of radioactivity to measure density of sea water.—*WPA*

A Simple Automatic Sampler for Water. R. WILKINSON & R. BRIGGS. Chem. & Ind. (Br.), p. 886 ('53). Automatic apparatus for sampling water at frequent intervals over period of 24 hr or more is described. Apparatus consists of series of sampling units and battery-operated switchgear. Valve of each sampling unit consists of kinked rubber tubing kept in closed position by piece of fuse wire and is opened by blowing fuse wire. Water from aspirator bottle (12 oz) siphons out and simultaneously draws river water into sample bottle (8 oz). Apparatus has been used successfully on river bank where sample was lifted to height of 2′–3′. —*WPA*

Automatic Samplers. R. M. POWER. Sanitalk, **1**:4:11 ('53). 2 automatic samplers for collecting composite samples of water, sewage, or industrial waste waters are described. In first, samples are collected by revolving scoop so that volume collected is proportional to flow. Sampler may be run continuously, one sample being collected every 2 min, or timing device may be employed. This sampler may be used where flow can be directed through weir box or Parshall flume. Second sampler is suitable for taking 24-hr composite sample from lake or slowly flowing river. It consists of sample bottle connected with evacuated metal cylinder. Rate of flow of air from sample bottle to cyinder is controlled with needle valve, and hence rate of flow of water into sample bottle can be adjusted. Constant temperature is essential.—*WPA*

A Sea Water Sampling Bottle. R. L. I. FJARLIE. J. Marine Research, **12**:21 ('53). New water sampler is described and illustrated. It consists of light metal tube with hinged lid on each end, coordinated with rotating frame that holds 3 reversing thermometers. Tube is clamped to sounding line at top and hooked at bottom. Device below

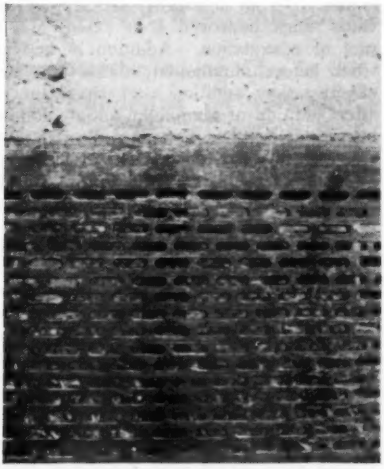
(Continued on page 70)



One of 6 Everdur screens made by Caisson Wells, Inc., ready to go in the ground. The wells have an effective diameter of 16 feet.

Durable well screens made of Everdur feature modern N. J. water system

Corrosion-resistant Everdur* was used for the screens in the 6 caisson wells that supplement the water supply of Manville, N. J. Everdur—the ideal material for well screens—was a big factor in permitting the use of this type of water system.



Made of ¼-inch-thick Everdur plate, circular screens are 18 inches high, having ¼-inch oblong perforations. Total open area is about 37%.

Caisson Wells, Inc., of New York City, did the job. Jordan S. Asketh of this company conducted the exploratory work. Wallace M. Graves, Consulting Engineer, Bound Brook, N. J., was in charge. Edward Purzicki was Waterworks Superintendent.

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Write for Publication DM 5120 describing Everdur Alloys and applications in detail. *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

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(Continued from page 68)

sampling bottle for releasing messenger when it closes allows any number of units to be used in series. Free flow of water through bottle has been facilitated by large openings at ends of tube. Relative efficiency of this sampling bottle with regard to flushing was compared with those of Knudsen, Nansen, and Ekman. Comparison, made in water with moderate salinity gradient, showed that new bottle was in equilibrium with surrounding water immediately, whereas there was measurable time lag for others.—*WPA*

The Use of Radioactive Isotopes for Flow and Velocity Measurements. Precautions and Possibilities of Use. ANTON MONTENS. Gas- u. Wasserfach, **93**:411 ('52). Half-life of Br^{38} in form of NH_4Br is long enough for practical measurements of water flow and yet short enough so that later users of water will not be endangered when several days elapse. Safe means of transporting isotope are discussed and app. is described for measuring activity of water to which it has been added. Isotopes especially useful in studying flow in sewage treatment plants, sludge flow in pipelines, etc.—*CA*

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CHEMICAL FEEDING, CONDITIONING, AND SEDIMENTATION

Theoretical Considerations and Experimental Findings on the Coagulation of Drinking Waters. R. BUYDENS. Tech. Sanit. Munic. (Fr.), **48**:139 ('53). Account given of theoretical aspects of colloid chemistry with reference to zeta potential, stability, and peptization of sols, and mutual coagulation of 2 sols. Paper discusses effect of temperature, pH value, and mixing on coagulation; action of chemical coagulants and of coagulant aids such as clays, silicic acid, and hydrophilic colloids; and influence of electrolytes on coagulation. Results are given of experiments on various waters with aluminium sulfate, with or without addition of coagulant aids. Coagulant was mixed vigorously with water for 1 min and slowly for 20 min, and water was examined after sedimentation for 5, 10, and 15 min. Turbidities were compared by measuring light absorption in spectrophotometer. Tests were made with clear water, water containing clay in suspension, polluted river water, and quarry water containing suspended mineral matter. In all instances, addition of activated silica improved both extent and the rate of coagulation. Addition of activated silica before alumimium sulfate was more effective than addition after coagulant. If, after addition of aluminium sulfate followed by activated silica, floc was allowed to develop for 10 min and small amount of aluminium sulfate was then added, large floc formed immediately. These results are apparently explained by greater probability of collisions of colloidal particles of active silica with free aluminium ions than with colloidal alumina particles. However, for waters containing large amounts of colloidal organic matter, reverse order is preferable, as very rapid coagulation is not desirable. Experiments were also made using carboxymethyl cellulose as coagulant aid. It was less efficient than activated silica and, with exception of polluted river water, gave better results when added after aluminium sulfate. Hydrophilic colloid apparently has sensitizing action on micelles of aluminium. When

(Continued on page 72)

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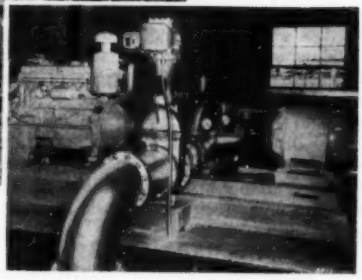

Photo shows Wheeler-Economy 10 x 8 Type M Pump at Santa Barbara Pumping Station, Albuquerque, New Mexico. This is a dual-drive (natural gas engine and electric motor) pump operating at 2800 GPM. General Contractor, Brown-Olds Plumbing & Heating Corp.

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(*Continued from page 70*)

added in concentration of 0.5 mg/l after aluminium sulfate, carboxymethyl cellulose produced good floc, which increased in size with time and settled rapidly.—*WPA*

Modified Sodium Silicate as a Coagulant Aid for Thames-derived Water. J. R. B. Griggs & G. C. Hicks. J. Inst. Wtr. Engrs., **7**:435 ('53). Paper gives details of laboratory and pilot plant tests made from May '49 to Aug. '51, during which period both raw and treated Thames waters were examined chemically, for bacteria, for filtrability, and by tintometer. Pilot vertical-flow sedimentation tank treated 500 gph with theoretical upward velocity of 4 fph. Dose of up to 60 ppm of alum alone produced poor floc, but good 9'-thick blanket was formed by dose of 30 ppm of alum added 3 sec after dose of 2 ppm of modified silica (made by adding sodium silicate to sodium bicarbonate solution or hydrochloric acid to sodium silicate solution, stirring for 5 min at 1 rps and 5 min at 0.5 rps, and aging for 1 hr). Other coagulants tested were alum alone, ferric chloride, alum plus sodium aluminate, alum plus modified sodium silicate, alum plus precipitated chalk, and ferric chloride plus modified sodium silicate, all in varying doses. Tests showed that: [1] correct balance of chemicals depends on condition of raw water; [2] correct velocity at distributing cone near bottom of tank aids coagulation and control of settled heavy sludge; [3] depth of floc blanket required depends on upward velocity; [4] absence of air is essential; [5] careful timing of desludging operations is necessary.—*PHEA*

Observations on the Removal of Radioisotopes During Purification of Domestic Water Supplies. G. E. Eden, A. L. Downing & A. B. Wheatland. J. Inst. Wtr. Engrs. (Br.), **6**:511 ('52). Small proportion of I^{131} activity was removed during normal coagulation of water with alum or with ferric salts, during subsequent passage through rapid sand filter, or during softening. Addition of 0.085 ppm silver nitrate before coagulation with alum resulted in removal of more than 90% of original activity when floc was separated by sedimentation. Greater proportion was removed when, after coagulation and partial sedimentation, water was treated by rapid sand filtration. Activity was readily removed from filter by backwashing, and water filtered subsequently was not seriously contaminated. When water containing I^{131} was passed through laboratory-scale slow sand filter, activity of effluent rose slowly during period of few days to about half of that in water before filtration. When filtration of uncontaminated water was resumed, radioiodine was discharged in filtered water for many days.—*H. E. Babbitt*

Studies of Sedimentation Basin Design. T. R. Camp. Sew. Ind. Wastes, **25**:1 ('53). Author discusses principles of sedimentation and their application in design of sedimentation tanks for treatment of water, sewage, and industrial waste waters. Causes of flocculation and turbulence in tanks and their effects on efficiency of removal of suspended solids are considered. It is concluded that flocculation more than compensates for retardation of removal by turbulent diffusion. Scour of sludge from bottom of tank is not considered of importance in properly proportioned tanks, even with velocities as high as 12–18 fpm. Short-circuiting is often measured by introducing slug of dye or other tracer at inlet end of tank and measuring concentration of tracer in effluent. Concentration-time curves are given for various types of tank to show short-circuiting characteristics, and curves are interpreted in terms of efficiency of sedimentation and required detention period. Various types of tanks which incorporate best principles of design are illustrated, and their use for specific purposes is indicated.—*WPA*

Flocculation and Flocculation Basins. T. R. Camp. Proc. ASCE, **79**: Sep. No. 283 ('53). Author discusses theory of coagulation in treatment of water, sewage, and waste waters, including effects of short-circuiting and flocculation by aeration with diffused air, by rotating blades, and by reciprocating blades. In appendix data are given on design and operation of coagulation tanks in 20 water treatment plants in US.—*WPA*

Studies on Aeration. Pt. I. E. B. Chain et al. 1st Intl. Symposium on Chem. Microbiol., World Health Org., Geneva, Switz., p. 73 ('52). *A. Factors influencing aeration efficiency.* Study has been made to compare, on quantitative basis, efficiency of different

(*Continued on page 74*)

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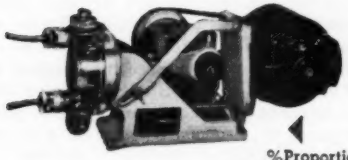

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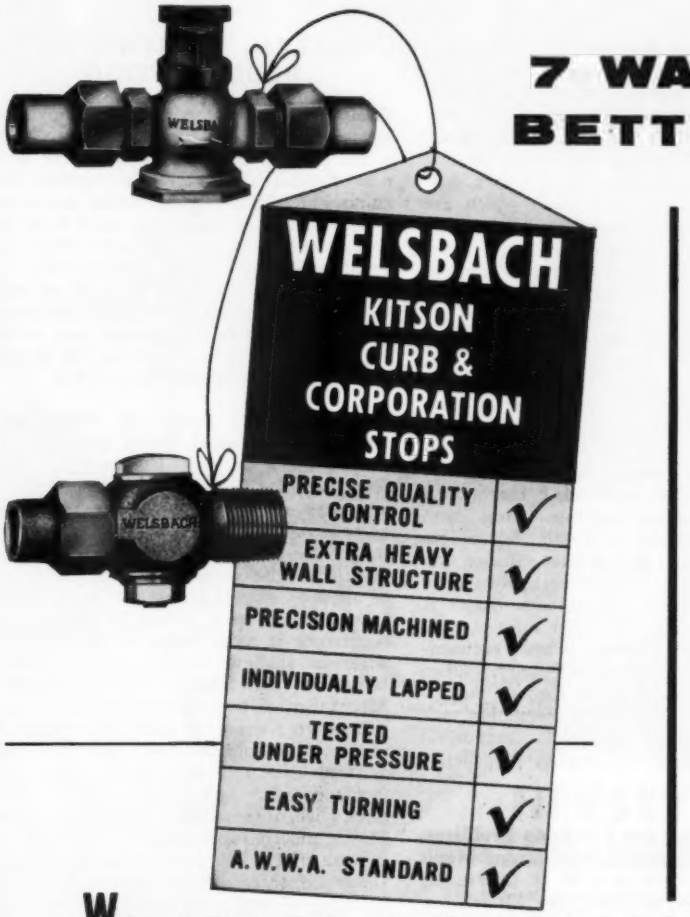
(*Continued from page 72*)

systems of aeration. Oxidation of sulfite to sulfate in presence of copper catalyst was chosen as means of assessing degree of aeration. This reaction is rapid, and limiting factor of reaction velocity is rate of diffusion of oxygen into liquid. Within wide limits, rate of reaction is independent of concentration of sulfite. Uptake of oxygen was measured by determining reduction in concentration of sulfite by iodometric titration at intervals of 15 or 30 min. Power absorbed for mechanical agitation of liquid was measured by means of dynamometer. Aeration efficiency of different types of air diffusers with different rates of flow of air was first studied without agitation of liquid. Aeration with ring diffusers and with single-orifice diffusers was poor even with high rates of air flow. Most efficient aeration was achieved with porous diffuser. Efficiency of aeration was greatly increased by mechanical agitation in presence of baffles. No significant difference was observed in efficiencies of small ring diffuser and single-orifice diffuser, indicating that number of holes in diffuser, within limits of 1–90, had little effect on efficiency of aeration. Large ring diffusers were much less efficient than small ring diffusers. It has been found that degree of aeration in fermentation tank could be doubled by reducing diameter of ring diffuser. In fermentation tanks, however, single-orifice diffusers are preferable to ring diffusers as higher rate of flow of air prevents them from becoming clogged with mycelium. In mechanically agitated, baffled aeration systems, porous air diffusers are much more efficient than other types of diffuser but also tend to become clogged and are difficult to clean. Studies made on relation between degree of aeration and power consumed by mechanical agitation with propellers of different diameters showed that, for propellers above certain diameter, all energy is utilized for aeration. For propellers less than certain diameter, relation between power and aeration is directly proportional only for relatively low power input. Presence of baffles is of importance in increasing aeration. *B. Aeration by free agitation (vortex system).* When liquid is agitated by rotation of propeller in absence of baffles, vortex develops. It has been observed that at apex of vortex air is dispersed as very fine bubbles, and studies were therefore made to determine degree of aera-

(*Continued on page 76*)



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(Continued from page 74)

tion achieved by this process. For vortex aeration linear relation was found between oxygen uptake and rate of rotation of propellers. As relation between power consumed and rate of rotation is also linear, it is concluded that there is direct relation between uptake of oxygen and power consumption, for rates of rotation which are of practical importance (1,000–2,000 rpm). When propeller is rotating at height about halfway up liquid, degree of aeration obtained was almost equal to that obtained when propeller was near bottom of liquid, and power consumption was less. Effect of inclination, height, length, and number of propeller blades on aeration was investigated. Blades inclined at 90 deg to plane of rotation showed better performance than blades inclined at 45 deg. Height of blades had little effect on efficiency of aeration. Optimal number of blades was 8, and optimal diameter of propeller was found to be about one-third of diameter of vessel. Advantages of vortex aeration system over diffuser system are discussed. For low rates of uptake of oxygen, diffuser system with baffles is slightly better, but, for higher rates of oxygen uptake, vortex system is more economical in consumption of air and power. When vortex system is used, no foaming occurs. On basis of these studies fermentation tank has been designed in which aeration is achieved by means of rotating propeller.—*WPA*

Water Softening and Condition Problems. Solution by Chemical Equilibrium Methods. D. H. CALDWELL & W. B. LAWRENCE. Ind. Eng. Chem., **45**:535 ('53). By utilizing equilibrium methods of physical chemistry, authors have developed method of solving water softening and conditioning problems with diagrams. Diagrams are worked out for temperatures of 25°C and 100°C. They show, step by step, methods used in developing them. Three examples of use of diagrams are worked out: [1] lime and soda ash dosages required to produce water of min. alky. with certain calcium content; [2] lime requirements to produce water of min. alky.; and [3] investigation of effect of softening water with lime alone, lime and soda ash, and sodium hydroxide alone. Comparison of graphic method and experimental results is given.—*PHEA*

HEALTH, HYGIENE, AND FLUORIDATION

Study of a Case of Alteration of Ground Water by Oxidized Pyrites. A. LECRECQ & M. NEVEU. Eau, **4**:56 ('53). At farm near Rennes, sickness among humans and animals and dying-off of growing vegetables were found to be caused by water from recently constructed well. Soil contained large amounts of iron pyrites. During long dry period pyrites had been oxidized to iron sulfate, and during subsequent prolonged period of rain this was leached out, giving very acid ground water containing ferrous salts in toxic concentrations.—*WPA*

A Geographical Study of "Swimmers' Itch" in the United States and Canada. S. JARCHO & A. VAN BURKALOW. Geog. Rev., **42**:212 ('52). Skin eruption developing after swimming or wading in certain lakes in midwestern US and Canada, known technically as cercarial or schistosome dermatitis, is disease of place; that is, it can be acquired only at certain places and is not communicable from person to person. Its occurrence is more severe in children who wade in shallow onshore waters (where larvae are most abundant) than in adults. Mechanism of transmission involves trematode worm; definitive host, either bird or mammal; intermediate host, snail; and man, accidental intruder into cycle. This is 4-factor complex and may involve 5th, bacteria, when secondary infection occurs. Major endemic area extends from parts of US near Great Lakes northwest into Canada. General distr. of reported cases suggests that infection of snails occurs during migration of aquatic birds and that outlying foci arise by birds crossing over from one flyway to another. Reported cases in Tenn. Valley Authority area, where migratory waterfowl were formerly uncommon, coincides with increased use of this area by birds from Mississippi flyway. Cases of proved cercarial dermatitis are acquired in lakes; rivers are less favorable, and there are no proved marine cases. Physical environmental factors influencing dermatitis distr. are multitude of lakes and sloughs within area of Pleistocene glaciation. Here are breeding grounds of migratory waterfowl, center of present distr. of fresh-water pulmonate mollusca, and environments more or less favor-

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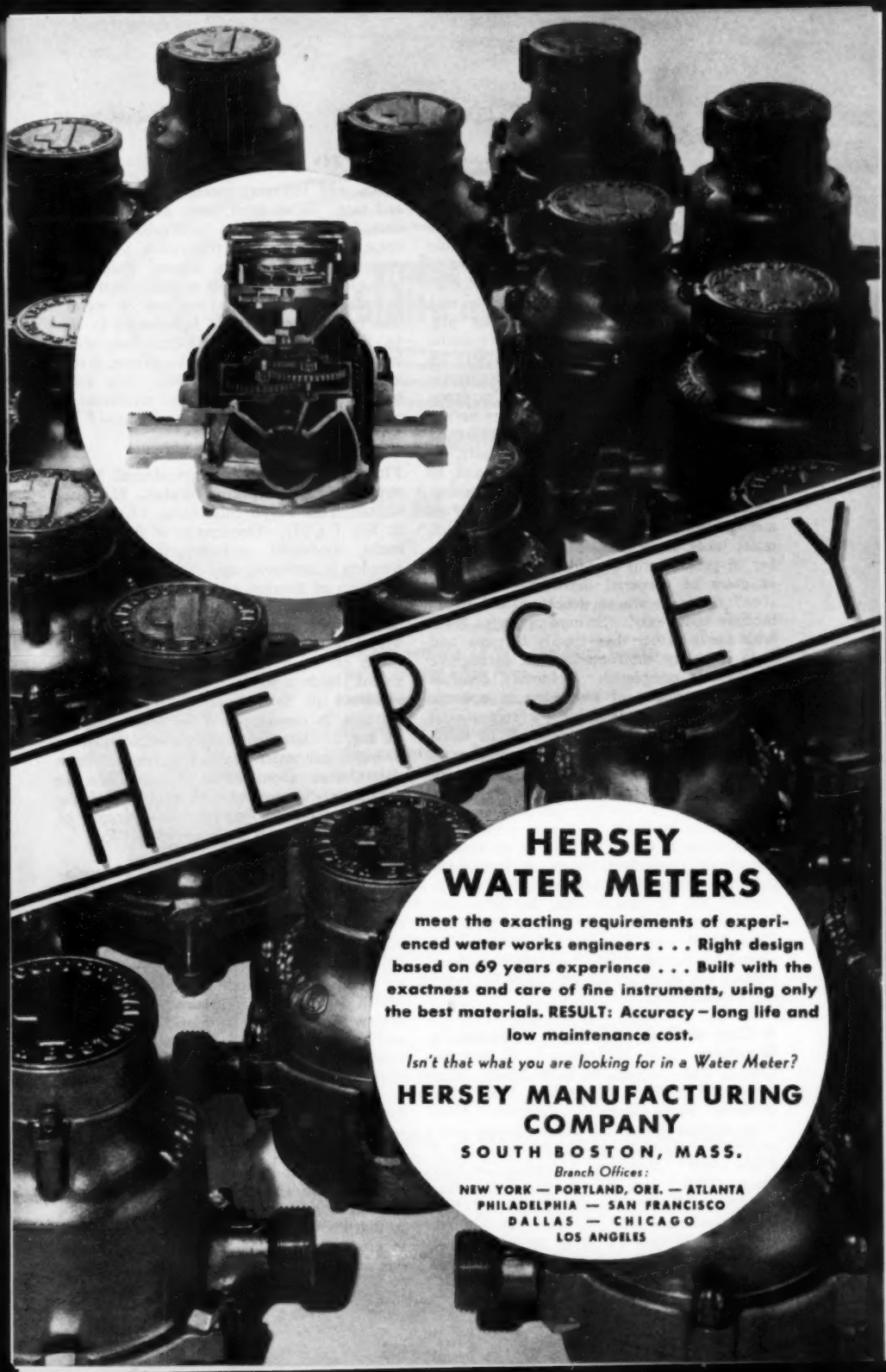
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(*Continued from page 76*)

able for schistosomes, including most important, *Stagnicola emarginata*. Larger glacial lakes, with clear water and sandy beaches relatively free of vegetation, are suitable habitats. Chemical composition of water is important in limiting distr. of snail and cercarial dermatitis; neutral or moderately acid pH is less favorable than alkaline pH. Wave-swept beaches are unsuitable; snails and dermatitis are more widely distr. on leeward shores. Max. infection of dermatitis occurs in mid-July and August. Incidence of schistosome infection of snail hosts varies. This may be due to variation in number and distr. of snails, to pollution of water, to migratory behavior of bird hosts, and to habits of man. Human factors influencing distr. of dermatitis include increased use of automobiles and development of roads, which make lakes more accessible to greater number of people; this provides rise in number of cases of cercarial dermatitis in "silent zone" or areas where definitive and intermediate hosts exist. Swimmers prefer lakes with sandy rather than muddy bottoms, and it is in sandy environment that pathogenic complex is completed. Voluntary controls include restriction of swimming in endemic areas, which is undesirable for recreational and financial reasons, and control of static host (snail) by use of Cu, which may be impractical in large lakes. Involuntary influence on distribution by bird hosts is due to reduction of breeding grounds through agriculture, lowering of water tables, and introduction of carp. In spite of decreasing waterfowl population, cases of swimmers' itch are increasing, partially due to increased use of larger lakes by birds and impounding of water for various purposes. Thus silent zone of cercarial dermatitis is spreading farther south, and more summer visitors are gaining access to lakes in northern endemic areas.—*PHEA*

A Case of Suspected Algal Poisoning in Manitoba. J. A. McLeod & G. F. Bondar. Can. J. Pub. Health, **43**:8:347 ('52). One horse and 9 dogs died within 1 hr after drinking water from L. Dauphin, Man. Area contained intense algae blooms consisting of: *Aphanizomenon flos-aquae* (L.) Ralfs (99%), *Anabaena flos-aquae* De Brebisson (0.9%), and *Microcystis* (*Polycystis*) *aeruginosa* Keutz; emend. Elekin (0.1%). Samples of lake water, as taken and filtered, and resuspensions of algae after freezing, grinding, and drying, were administered orally and intraperitoneally to white mice and rats. In all fatal cases, algae introduction was followed by paralysis, muscular spasms, and impaired respiration producing cyanosis. These expts. showed that algal poisoning caused death of animals; that toxic material was in plants and not in water; that toxic material might be released to water with disintegration of plants, but, while in plants, it is not destroyed by drying, freezing, or ultraviolet irradiation. Not detd. how long it lasts under natural conditions or what its ultimate fate is in nature.—*F. J. Maier*

Fluorine in Swedish Agricultural Products, Soil, and Drinking Water. H. Nommick. Acta Polyt. Stockholm, Chem. Ser., **3**: No. 7 ('53). Occurrence of fluorides in rocks, foodstuffs, and drinking water in Sweden is reviewed, and methods for determination of fluorine are discussed. Concentration of fluoride in water from wells increases with increase in depth of well and with increase in total concentration of salts. Study on occurrence of dental caries in 8-yr-old children in 48 parishes showed that incidence of dental caries decreases with increase in concentration of fluorine up to 1.0 mg/l. Data on concentration of fluorine in municipal water supplies in Sweden have shown that about 64% of population in urban areas is supplied with water containing less than 0.2 mg/l fluorine. Bibliography of over 200 references is appended.—*WPA*

Public Health Aspects of Water Fluoridation. G. Nikiforuck. Can. J. Pub. Health, **45**:2:43 ('54). Present status of fluoridation involves increasing acceptance by communities with concurrent increase in opposition. Seemingly contradictory events tend to confuse public and create difficulties in health depts. doing promotional work. This review of basic facts on fluoridation is aimed at clarifying situation. Concludes that ramifications of procedure are numerous and investigations into these are never complete. However, large no. of completely negative findings on toxicity of fluorides in recommended dosages, and irrefutable evidence regarding its value in caries reduction, justify conclusion that evidence as whole is consistent in offering assurance that bringing fluoride concn. in communal water supplies to that known to be optimal for dental health is prophylactic public health procedure that has ample margin of safety.—*F. J. Maier*

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(Continued from page 46 P&R)

The water wagon is free wheeling, or just about free, anyway, when compared to the liquor lorry. That ought to be awfully obvious to anyone who has plunked down half a day's pay for a quart of the strong stuff, but if more objective evidence is required, it's on the books now in the analysis of 1953 municipal liquor store operations in Minnesota which appeared in last July's issue of *Minnesota Municipalities*. The figures there for 368 municipalities, with some 450,000 population, show gross sales of $34,440,000, just about $75 per capita, and net profit on these sales of $5,856,000, $12.50 per capita. If public water supplies were to collect the same cash from those same people even for the 23,500,000,000-gal snootful served to them in the same period, the profit would come to $250 per mil gal on a selling price of $1,500 per mil gal. Or looking at it even more spectacularly, if those per capita income figures were applied to the nation's water supply utilities, their sales would run to $7,500,000,000—approximately $1 for every $1 of investment in plant rather than the present $1 sales for $9 investment, though still ten times worse than the liquor store score of a dollar per dime. As for profits, at $1,250,000,000, they'd be considerably higher than present total sales, and water works superintendents would be taking their Cadillacs to AWWA conventions merely to give their chauffeurs an outing.

Of course, if adopting the profit scale without the product seems too incongruous, why not adopt the product too and make a combined utility of it—the whisky and water department, that is, or, more subtly, the department of hard and soft beverages? Not only would such a department's profits be quite respectable, but it just couldn't lose when softies were driven to drink or when drinkers went on the water wagon. "If you can't hold our liquor, you can hold our water!" may not be the best slogan, but the possibilities for combined product promotion would be almost endless. No more free wheeling then—as a matter of fact, nothing free and a lot of big wheels.

On the water wagon, meanwhile, but with both feet on the ground, is Los Angeles, achieving what has been dismissed as either impossible or uneconomical in other of the nation's largest cities. Which is to say that the 683,500,000 gal which set a new water consumption record in L.A. last July 8 was 100 per cent metered. That means that sales ran to an average of 300 gpcd, more than twice the nation's year-round average. In a city with an ocean on one hand and Hollywood's glamorous bars on the other, that must be salesmanship, even at water rates.

"Clean Waters," the General Electric Co. film on water pollution, has been revised and in its new version will be shown at the FSIWA convention in Cincinnati this month. The 16-mm sound and color film has a running time of 25 min.

A masonry hole-cutting machine, designed to cut ½- to 10-in. holes in concrete up to 18-in. thick, is offered by Molco Drilling Machines, Inc., 1100—20th St., N.W., Washington, D.C. The diamond drilling bits are said to cut a 6-in. hole through a foot of concrete in less than 2 min.

(Continued on page 82 P&R)

Model DVS manually controlled Chlorinizer installed at Estacada, Oregon — Supt. Glen Ebert at left, Mayor Ford A. Darrow, at right.

CHLORINIZER Made a Big Difference in the Small Town of Estacada, Oregon

For the 1,000 people of Estacada, this Builders Model DVS Chlorinizer represents an important municipal economy. Previously another type of equipment had cost up to $10.00 a month in heating bills alone to overcome a serious "chlorine ice" problem. With the Chlorinizer, safe and dependable chlorination has been maintained even when water temperature dropped to 33°F. and air temperature stood at 17°F. . . . further proof of the advantage of metering and controlling chlorine gas in the dry, inert state.

Since early 1953 when the installation was made, the Chlorinizer has been in service continuously, and has required almost no maintenance. In a town of this size, municipal budgets cannot afford specially trained chlorination maintenance men. The Chlorinizer has operated since installation completely without need for specialized personnel.

More and more, the trend is to Chlorinizer, for new projects, for replacement, for plant expansion. Find out for yourself why this safe, simple, dependable chlorine gas feeder will save you money and serve you well. Write for descriptive Bulletins. Builders-Providence, Inc., 365 Harris Avenue, Providence 1, Rhode Island.

Mayor Ford A. Darrow of Estacada, Oregon states, "We had considerable trouble with another make . . . and to date have had no trouble with Chlorinizer. We are entirely satisfied and would recommend this chlorine gas feeder".

BUILDERS-PROVIDENCE

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO.

BIF METERS FEEDERS CONTROLS

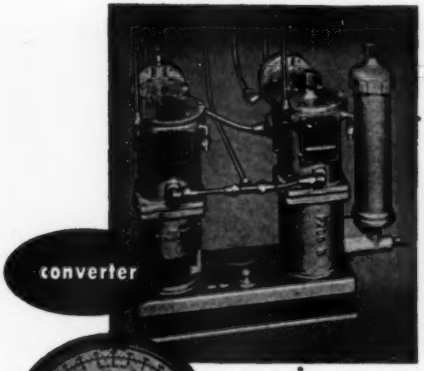
(Continued from page 80 P&R)

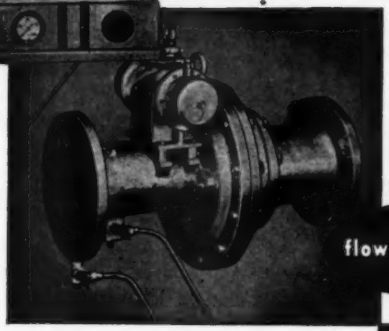
Willing Water, we had always thought, made the ideal apologist at the barricade, the almost certain turner awayer of wrath, with his explanations of why the torn-up street and how "it's really good for you!" But Fenton Industries of Los Angeles have suddenly given us pause with what "they believe to be the only all-steel barricade on the market" and we are sure is the only blond one! (see cut again). "An exclusive light-locking feature," says Fenton, "prevents theft of the light." (Oh! those light locks!) "Twice as easy to haul or store, nailless, splinterless, with 10 times the life expectancy," the telephone number is HOllywood 2-0714. Order yours today.

Cold phosphating of corroded iron and steel is offered by FerRoSeal, a liquid which is intended to be applied to rusted surfaces to prepare them for coating or painting. A chemical reaction which converts the corrosion products into a protective iron phosphate coating is said to eliminate the need for pickling or cleaning—other than wire-brushing. The protective action, according to the makers, the Chemical Div. of Municipal Steel Corp., 1225 Broadway, New York 1, N.Y., extends paint life three to five times.

It's Long Suffern now, seven long months after the Battle of the Bilge, wherein the village of Suffern, N.Y., brought its police force, a State Supreme Court suit, and an aroused public to bear on the problem of preventing the New York State Thruway Authority from relocating the polluted Ramapo River within seepage range of the village's three new artesian wells (*see* December 1953 P&R p. 34). At that time, the Authority presumably surrender, agreeing to adopt a course satisfactory to the village. Now, however, seven short months later, village officials have had to call out the cops again, Authority personnel having abrogated the treaty by running the new river bed at a position contrary to the agreement and then calling in their underground experts to prove that contamination couldn't result, because the flow is away from the wells. Since the village has its own "recognized water experts of national repute," who have proved that the water supply does come from the direction of the new river bed, the battle seems definitely rejoined. Will the Thruway go through? Will Suffern suffer? Tune in next month and become long-suffering too!

(Continued on page 84 P&R)





C.-A.-P.

Controlled Air Pressure

SYSTEM

instant, accurate measurement of head and flow... plus automatic flow control!

Your operation is only as efficient as your measurement and control methods. The C.-A.-P. System provides an accurate measure of head loss and flow and an instantaneous, automatic adjustment of flow rate. Controlled Air Pressure eliminates inaccuracies of stuffing boxes and complex equipment of diaphragm or mercury operated gauges.

See For Yourself...

get this detailed C.-A.-P. bulletin complete with drawings. Ask for Bulletin 1100-J.

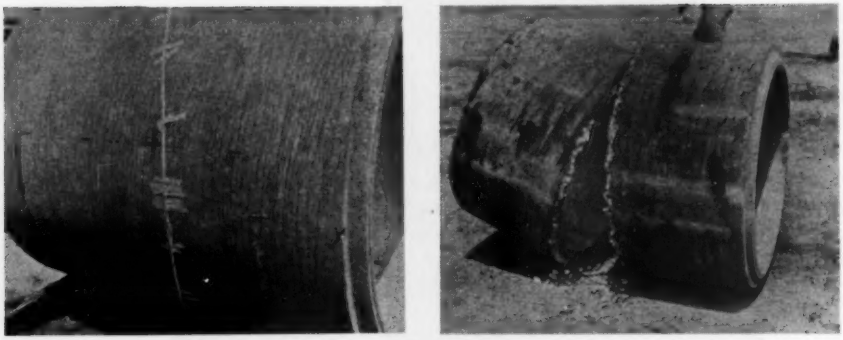
INFILCO

INFILCO INC. | *Tucson, Arizona*

Plants in Chicago & Joliet, Illinois

FIELD ENGINEERING OFFICES IN 26 PRINCIPAL CITIES

(Continued from page 82 P&R)



Blast-Cutting of Concrete Pipe—Before and After

Using explosives for field cutting of reinforced concrete culvert pipe is being tested by United Concrete Pipe Corp. of Baldwin Park, Calif. The method (see above) involves wrapping primer cord around the pipe in a carefully determined position, detonating it with electric blasting caps, and chipping away the concrete and cutting the reinforcing steel within a 1-in. area, to obtain clean edges. Although the method is still experimental, and has the obvious drawbacks associated with use of explosives, it appears it may save upwards of 75 per cent of labor costs, as well as yielding cleaner edges with less destruction of pipe.

Universal Concrete Pipe Co. has moved its eastern sales office from the Graybar Bldg., New York, to its plant at 85 Harbor Rd., Port Washington, L.I. The telephone number remains the same: MUrray Hill 4–4502.

Gallon Passes Bar: Stanley J. Gallon, escrow officer in the Land Div., on July 27 passed the California State Bar, which gave him the right to practice law in all state courts.—*Intake, Los Angeles Dept. of Water & Power, Aug. 1954.*

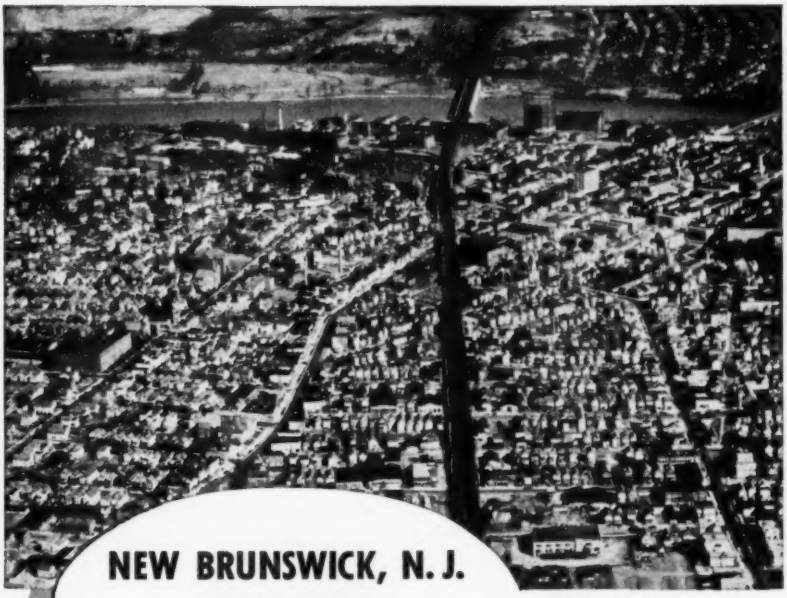
One way to keep out of the jug!

Hungerford & Terry, Inc., is completing a new plant at its Clayton, N.J., headquarters to provide additional manufacturing capacity as well as laboratory and office space.

Frederick R. Gruner has joined the Warren Foundry & Pipe Corp. of New York as vice-president in charge of operations. He was previously associated with Allis-Chalmers Mfg. Co. of Milwaukee, Wis.

B–I–F Texas, Inc., has been organized as a Southwest Div. of B–I–F Industries, Inc., and will represent Builders-Providence, Inc., Omega Machine Co., and Proportioneers, Inc., in the Southwest. The main office of the new division will be located in Houston, Tex., and will be staffed by John B. Mackenzie Jr., vice-president, and Charles J. Wolfer, Raymond W. McIndoe Jr., and Mrs. Lollie R. Lowe. At Dallas a branch office will be staffed by former members of the firm of Morey and Morey, which for 33 years represented the B–I–F interests in the Southwest: Edward Morey Jr., vice-president, Lewis H. Johnson Jr., and Mrs. Floy Brazell. In addition, the Dallas staff will include Richard L. Lauderdale and Clem D. Hoye Jr.

(Continued on page 86 P&R)



NEW BRUNSWICK, N. J.

EQUIPS 8 FILTERS

with

POROUS UNDERDRAINS

Information courtesy
Mr. Chris C. Condon, Superintendent,
New Brunswick, Water Department.

A dozen years ago New Brunswick had mushroom strainers in all their gravity filters. They also had an acute case of sand clogging. Dangerously high pressures were often needed to clear the sand. And at best, backwashing was uneven. Mudballs and upset gravel were constant problems.

In 1943, they started to modernize their filters. They installed porous underdrains, using ALOXITE® aluminum oxide plates—one filter in 1943; one in '44; two in '46, two in '48; and two in '50. Today, all their filters have ALOXITE underdrain plates, and their previous difficulties have been eliminated. Backwashing now takes five minutes and only 5000 gallons of wash water per unit, where it used to take 12 minutes and twice as much water.

Our congratulations to New Brunswick on a well planned and executed program of modernization. The low operating and maintenance costs of their porous-plate underdrains should be tremendous assets for years to come.

Send for free 56-page booklet.

CARBORUNDUM

Registered Trade Mark

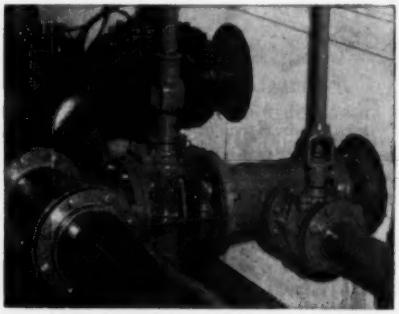
Dept. 0-104, Refractories Div. The Carborundum Co. Perth Amboy, N. J.

(*Continued from page 84 P&R*)

A utility and foundation ditcher (above), Buckeye model 403 of Gar Wood Industries, Wayne, Mich., is claimed to make possible lower cost service line construction for basementless houses. The ditcher can dig a 5-ft trench 8, 10, or 12 in. wide, or a 4-ft trench 14 or 16 in. wide.

Water has joined sin this election year as one of those issues about which there is always complete unanimity on ends, but often just as complete disagreement on means. Down Texas way, the ends have it—both gubernatorial candidates repeatedly stressing the need for an adequate long-range water program, although, as Governor Allan Shivers, himself, put it: "A good three-inch rain would be worth much more to Texas than all the political hot air that has blown across the state." Up in New Jersey, on the other hand, it has definitely been a means test, one panacea after another having been battled out in the Legislature over the past few drought-ridden years and every legislator having some pet pat solution. Latest of the casualties of this means melee was an $85,000,000

(*Continued on page 88 P&R*)



ONE INSTALLATION AFTER ANOTHER SPECIFIES

DEZURIK PLUG VALVES

Every day, more and more DeZurik Valves are being installed in new plants or being specified to replace worn-out valves in existing plants. As intake, discharge and backwash valves on sand filter beds, DeZurik Valves insure tight shut off despite sand and silt in the flow and resist the abrasive action of suspended matter. Available in lever, gear or remotely operated models, and in sizes thru 20". Write for details.

REPRESENTATIVES IN PRINCIPAL CITIES

DEZURIK SHOWER CO. SARTELL, MINNESOTA

GENERAL FILTER'S

case history files

WILL HELP YOU SOLVE

ANY *water conditioning* PROBLEM

Granted . . . no two water treatment problems are ever exactly alike. Every installation requires individual, specialized attention . . . the composition of the water, rate of flow, local conditions and desired results must all be studied before recommendations are made. However, our authentic case history files of thousands of different installations may cover many of the problems you encounter. A problem that is new to you may be old to us. Save valuable time by checking with General Filter Company first on your water treatment problems. There's no obligation and we'll be glad to give you all the help we can. Write us today!

General Filter Company

AMES, IOWA

. . . better water

write for these FREE booklets today!

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DEPT. 00000, AMES, IOWA

Gentlemen: Please send us further information on the subjects checked below:

- ☐ AERATORS
- ☐ FILTERS
- ☐ TASTE AND ODOR
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- ☐ HIGH CAPACITY RESINOUS ZEOLITE
- ☐ IRON RUST REMOVAL
- ☐ DEMINERALIZATION
- ☐ SOFTENERS
- ☐ HAVE ENGINEER CALL
- ☐ _____

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

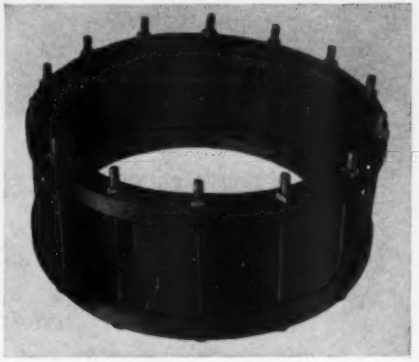
CITY _____ ZONE _____ STATE _____

(Continued from page 86 P&R)

bill intended eventually to provide for construction of two huge reservoirs to augment supplies in both North and South Jersey. With water continuing on the critical list every summer, especially in the North Jersey metropolitan area, the struggle is bound to intensify with the situation, until North and South, rural and urban, Republican and Democratic, big reservoir and little reservoir are forced to agree on something. Meanwhile, with the drought getting worse in Texas every year, meanslessness there will soon have to cease, too, in favor of specific projects of wider scope than the purely local measures now being taken.

As better water bills in the nation's legislatures are bound to mean bigger water bills in the voters' homes, however, it is unlikely that they will be spelled out too carefully until after the election. Sin, after all, is sin!

Less minimum is what Everett C. Post of Scotch Plains, N.J., wants—less of a minimum charge on his water bill, that is, to make his cooperation with the water conservation campaign, and its attendant lawn burning and inconvenience at least a little worth his while. What gripes Post most is that in managing to cut his water use to a mere 800 cu ft last quarter, he was played for a sucker by his neighbors, who used up to 50 per cent more and still paid the same amount. Public-relations-wise, at least, there is merit in his madness, and those who would encourage water conservation campaigns might do well to suspend minimum charges for the duration. Perhaps our Scotch Plains friend is just plain Scotch, but who could conserve better? As a matter of fact, he ought to rate a bonus!



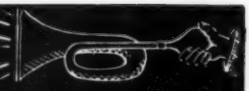
Flexible steel couplings for 24- to 96-in. pipe are being offered by R. H. Baker & Co., Huntington Park, Calif., with either rubber or neoprene gaskets.

The Millipore Filter Corp. has been formed for the production and further development of the MF Millipore filter membrane. The new company is headed by John H. Bush as president. The entire manufacturing and research staff which worked on the membrane filter for Lovell Chemical Co., Watertown 72, Mass., is now associated with the new company in the same location. Behind the organizational change is the company's conviction that the MF has passed beyond the experimental stage and is now a useful tool in bacteriological analyses, so that production should be expanded.

A new Chlorinizer, Model EVS, has been announced by Builders-Providence, Inc. The unit offers visible flow, only one chlorine diaphragm valve and a short, clear, chlorine path. The 8 to 1 metering range and a selection of units permits a choice of capacities from 4 to 400 lb per 24 hr.

(Continued on page 92 P&R)

YOU WERE DOING THIS



WHEN THE FIRST HYDRO-TITE JOINTS

WERE BEING POURED -

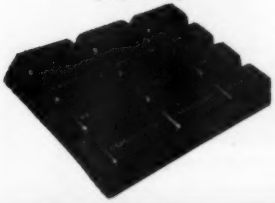
HYDRO-TITE
(POWDER)

HYDRO-TITE

(POWDER)

For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

HYDRO-TITE
(LITTLEPIGS)



HYDRO-TITE

(LITTLEPIGS)

The same dependable compound in solid form —packed in 50 lb. cartons—2 litters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX
(REELS)

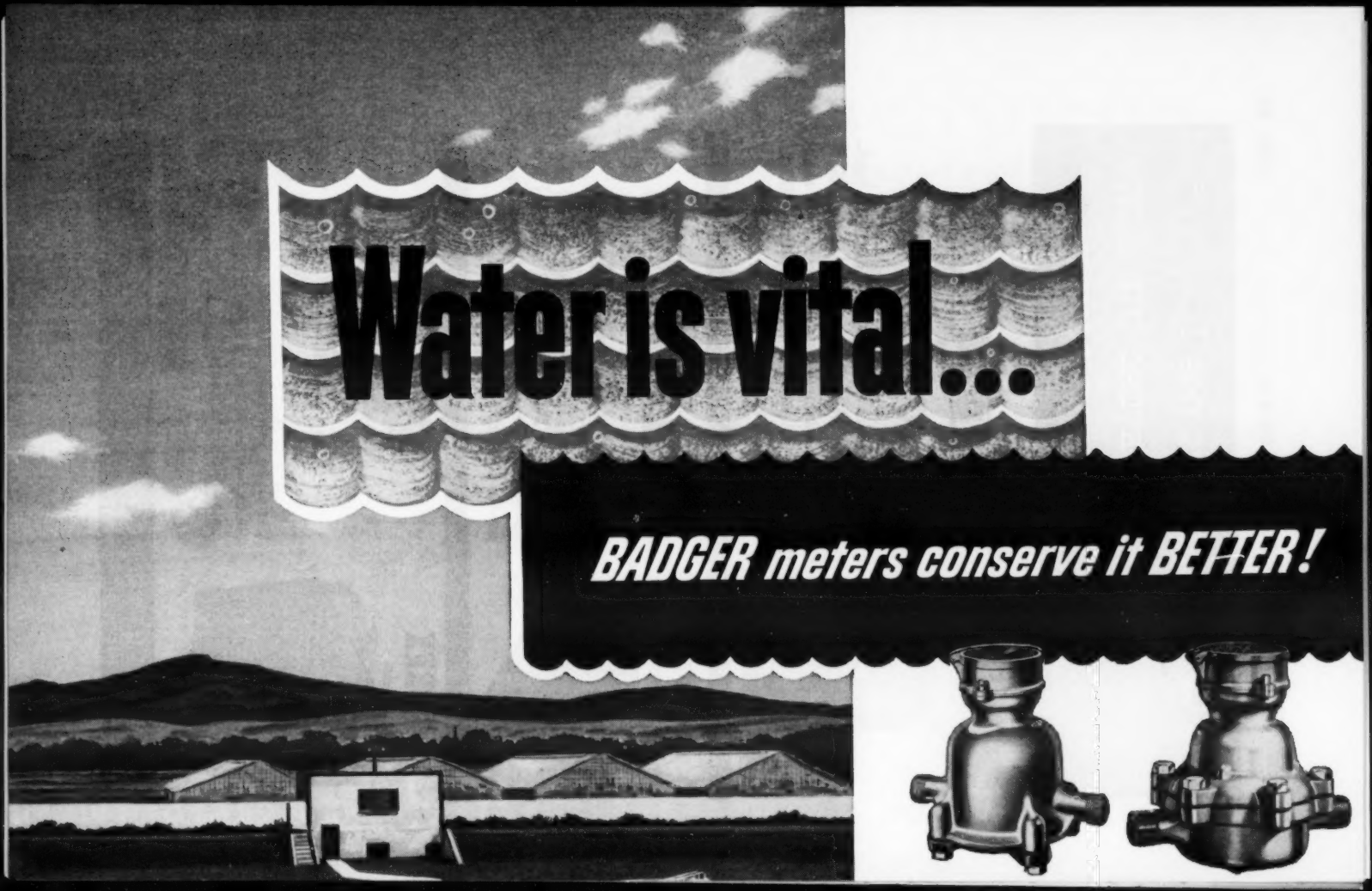
FIBREX

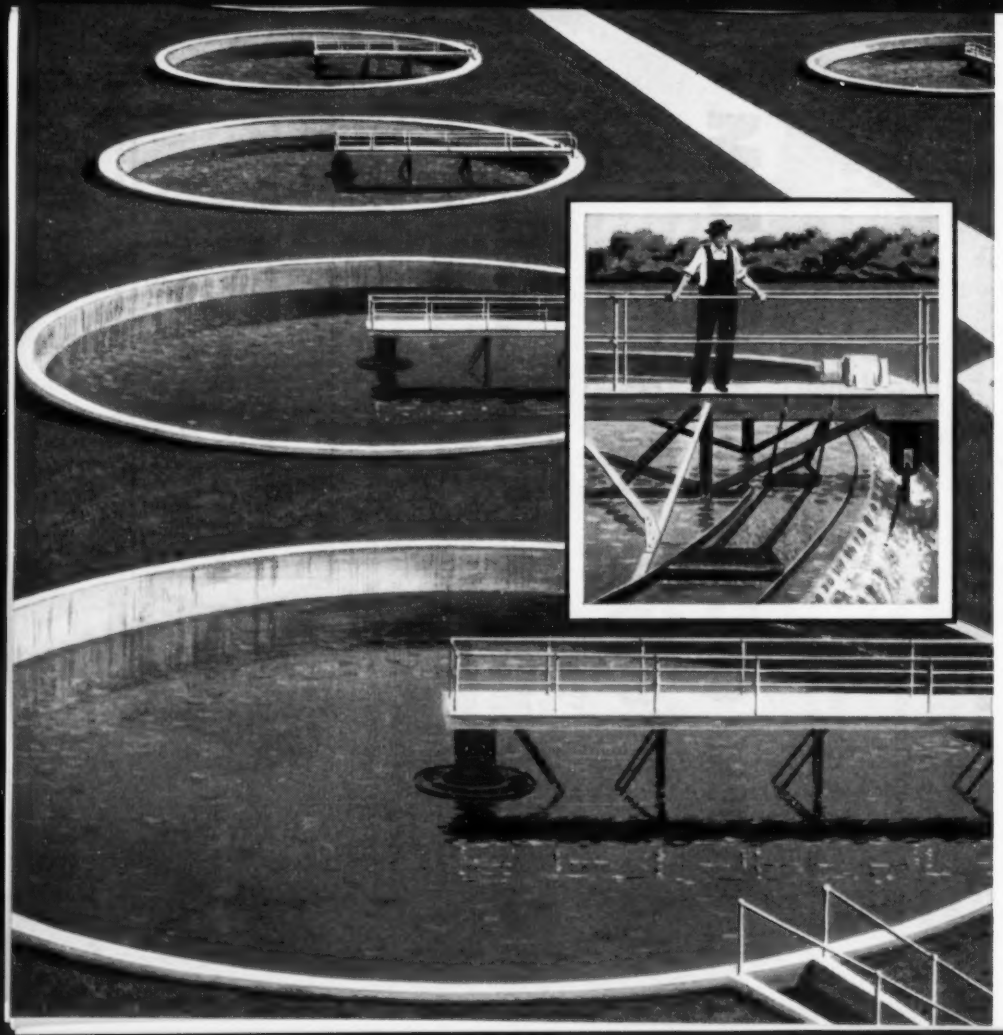
(REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.

HYDRO-TITE

HYDRAULIC DEVELOPMENT CORPORATION


Water is vital...
BADGER meters conserve it BETTER!



SANITATION is so vital to life that a city of three-quarters of a million people actually uses 134,000,000 gallons of water daily! In thousands of communities, famous Badger meters make certain that homes and industrial projects get their fair share of the supply . . . pay only for the water they use. Badger meters measure water precisely . . . help eliminate waste . . . make water departments more efficient and self-supporting. And, as waterworks men verify, Badger meters do the job dependably . . . serve for years with little or no attention.

BADGER
Water Meters

Badger Meter Mfg. Co.
Milwaukee 45, Wisconsin

"Measures the water of the world"

(*Continued from page 88 P&R*)

Remindful of Malenkovia was the onesidedness of the recent vote on AWWA's constitutional amendments, those to Sec. 3.1 being approved 1,391 to 14 and those to Sec. 3.3, 1,396 to 3.* Actually, the return of 1,412 ballots on issues as uncontroversial as were these provides a wonderful example of just the opposite of Malenkovism. And AWWA is happy to have a group of members as conscientious about the exercise of their franchise—not even disincluding the four who returned their ballots unmarked or the one who sent his in both unmarked and unsigned. Next month, the issues are likely to be rather more sharply disputed, but the vote, whatever it is, won't be no more gratifying to nobody!

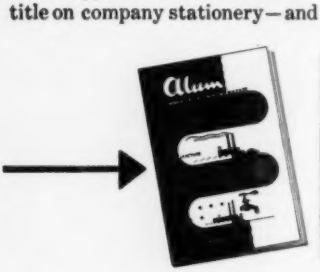
*3.2, of course, doesn't refer to water, although it did taste like it.

A proposed merger of the Dorr Co. with Oliver United Filters Inc. will be submitted to the stockholders of both companies for ratification. If approved, the merger will become effective Dec. 31, 1954, and the new organization will be known as Dorr-Oliver Inc. The new Board of Directors will be composed of equal numbers of representatives of the two companies, with Edwin Letts Oliver and John V. N. Dorr sharing the title of founder—chairman of the board. J. Delano Hitch Jr. is to be president and Edwin Letts Oliver Jr. and Douglas C. Reybold are to be administrative vice-presidents. The Dorr Co. has long acted as overseas agent for the marketing of Oliver United Filters Equipment, and the merger will unite their forces in production and domestic distribution as well.

Depend on Cyanamid's ALUM for 6 good reasons

1. It feeds uniformly, without trouble, in solid or liquid form.
2. It has a wide pH range for effective coagulation.
3. It forms floc rapidly.
4. It gives maximum adsorption of suspended and colloidal impurities.
5. It causes minimum corrosion of feeding equipment.
6. It is available in granular form or in the new easy-to-use liquid form.

For a copy of "Alum—Commercial Aluminum Sulfate," please send us your name and title on company stationery—and would you also mention where you saw this offer?

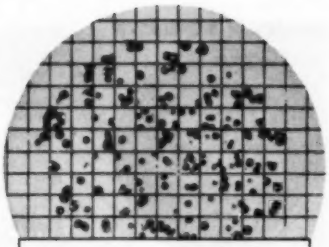


AMERICAN Cyanamid COMPANY
Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.

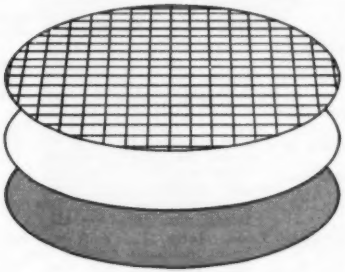
In Canada: North American Cyanamid Limited, Toronto & Montreal

Are you using MF Techniques for bacteriological analysis?

Isopor dehydrated nutrient schedules save laboratory time and expense



MF membrane with colonies of E. coli after 18 hours of incubation using ISOPOR dehydrated nutrient schedule.



A .... Molecular filter membrane, Type HA, 47 mm diameter, grid marked.

B .... Thin leaf of porous paper, impregnated with generally or partially stimulating nutrient.

C .... Disk of blotting paper, impregnated with inhibitory or secondary nutrient.

The known absorption qualities of papers used in ISOPOR Scheduled Nutrient Packs deliver nutrients to cultures on a time-controlled basis.

The use of ISOPOR Dehydrated Nutrient Packs allows users of MF techniques for hydrosol analysis to eliminate practically all intermediate steps in bacteriological analysis. After filtration, membranes are placed directly on rehydrated ISOPOR pads in a Petri dish and incubated. No intermediate steps are required. Tests are complete in 16-18 hours with only two pieces of sterile equipment (MF holder and Petri dish).

ISOPOR DEHYDRATED SCHEDULED NUTRIENT PACKS

Molecular filter membranes, complete with dehydrated nutrient schedules, sterile packed in polyethylene envelope.

ENDO . . . . . *(Coli-Aerogenes group)*
E.M.B. . . . . *(Coli-Aerogenes differentiation)*
GENERAL I . . . . . *(General nutrient with redox indicator)*
GENERAL II . . . *(General nutrient with redox indicator and fungus-yeast inhibitor)*
YEAST . . . . . *(Yeast-bacteria differentiation)*

ISOPOR STERILE MF PACKS . . . *Same as above, except with absorbent pad for impregnation with liquid nutrient.*

For further information, write to:

AG CHEMICAL COMPANY, INC.

Box 65C • Pasadena, California

See ISOPOR Ads on Pages 12 and 13.

CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received Aug. 1–31, 1954

Allan, L. B.; *see* Toronto (Ont.), Municipality of Metropolitan

Ashworth, A. H.; *see* North Vancouver (B.C.)

Batchelder, John P., Mgr., Township of Parsippany, Troy Hills, N.J. (July '54) *M*

Beamand, Roy K., Supt. of Utilities, Board of Public Affairs, Deshler, Ohio (July '54)

Binion, Richard, Jr., Public Health Engr. III, Div. of San. Eng., State Dept. of Health, 2411 N. Charles St., Baltimore 18, Md. (July '54) *RPD*

Blair, Charles T., Chief Engr., Wilsey & Ham, 1275 Rollins Rd., Burlingame, Calif. (July '54) *M*

Capon, Alan E., Prin. Utilities Engr., Public Service Dept., City of Burbank, 164 W. Magnolia Blvd., Burbank, Calif. (July '54) *MRD*

Carlson, Russell A., City Mgr., City Hall, Grayling, Mich. (July '54)

Clark, A. F., Supt., Munic. Water & Sewer Dept., 115—1st Ave., Waverley, Ohio (July '54) *MP*

Compton, August W., Partner, Clyde E. Williams & Assocs., 720 E. 38th St., Indianapolis, Ind. (July '54) *RPD*

Contra Costa County Health Dept., Thomas McMorrow, Director of Sanitation, 900 Court St., Martinez, Calif. (Corp. M. July '54) *RP*

Cowen, Robert C., Mgr., Gas & Water Dept., Clarksville, Tenn. (July '54) *MPD*

Croul, Jack H., Asst. Mgr. & Office Mgr., Lakewood Water & Power Co., 2965 E. Carson, Lakewood, Calif. (July '54) *M*

Dunlap, Walter T., Partner, Walter T. Dunlap & Co., Lexington, Neb. (July '54)

Evoy, George Harvey, Mgr., Hoosier Water Co., Sheridan, Ind. (July '54) *M*

Fallon, Raymond D., Salesman, Mueller Co., 601 Colorado Blvd., Denver, Colo. (July '54) *D*

Flynn, William J., Jr., Mech. Engr., Water Dept., 2811 S. Franklin St., Philadelphia 48, Pa. (July '54) *D*

Frame, Rollo S., Service Engr., Price Brothers Co., 1932 E. Monument Ave., Dayton, Ohio (July '54) *D*

Gischer, Walter W., Owner, Birch Bay Water Co., Rte. 1, Box 194-B, Blaine, Wash. (July '54) *MD*

Gonslor, William A., Sales Mgr., Pressure Pipe Div., Price Brothers Co., 1932 E. Monument Ave., Dayton, Ohio (July '54) *D*

Goodyear Atomic Corp., W. C. Underwood, Box 628, Portsmouth, Ohio (Corp. M. July '54)

Graham, Leland; *see* Graham & Bereman

Graham & Bereman, Leland Graham, Partner, 1737 Sheridan Ave., Box 444, Cody, Wyo. (Corp. M. July '54) *MP*

Haight, George W., Salesman, Rensselaer Valve Co., 5733 C N. Park Ave., Philadelphia 41, Pa. (July '54) *PD*

Halvorson, Norris O., Comr. of Finance, 113 City Hall & Court House, St. Paul 2, Minn. (July '54) *M*

Hanson, Archie E., Jr., Gen. Mgr., Hidden Hills Mutual Water Co., 23501 Ventura Blvd., Calabasas, Calif. (July '54) *MRD*

Hertzberg, Lee B., Assoc. Elec. Engr., East Bay Munic. Utility Dist., 2127 Adeline St., Oakland, Calif. (July '54) *D*

Hoffmeister, Richard A., Engr., Clyde E. Williams & Assocs., 720 E. 38th St., Indianapolis, Ind. (July '54) *PD*

Imbertson, N. M., Engr. in Charge, Mech. Eng. Div., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (July '54)

Jones, Lee R., Vice-Pres. in Charge of Operations & Constr., Colorado Central Power Co., 3470 S. Broadway, Englewood, Colo. (July '54) *MRP*

Kaessner, Howard L., Civ. Eng. Asst., Dept. of Water & Power, 207 S. Broadway, Rm. 826, Los Angeles 12, Calif. (July '54) *RD*

Kelser, C. R., Salesman, Western Water Works Supply Co., 2600 San Fernando Rd., Los Angeles 65, Calif. (July '54) *MD*

King, Carleton L., Structural Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (July '54) *R*

Krause, Charles W., Dist. Mgr., Neptune Meter Co., 19 W. 50th St., New York 20, N.Y. (July '54)

Kurtz, H. Hall, Supt., Roslyn Water Dist., 24 W. Shore Rd., Roslyn, N.Y. (July '54) *D*

Larkin, Daniel James, Sales Engr., Warren Foundry & Pipe Corp., 55 Liberty St., New York 5, N.Y. (July '54) *PD*

Lawfer, Lawrence P., Field Engr., Fischer & Porter Co., 646 Evans St., S.W., Atlanta, Ga. (July '54) *P*

Link, William E., Engr., Shenango Valley Water Co., Box 542, Sharon, Pa. (July '54) *MP*

Loos, John F., Jr., Sr. Asst. Engr., Baltimore County Div. of Eng., Towson 4, Md. (July '54) *D*

Lowe, Howard, Sr. Mech. Engr., Water Dept., 216 Court House, St. Paul 2, Minn. (July '54) *M*

Luce, John, Supt., Fort Smith Water Co., 504 N. 39th St., Fort Smith, Ark. (July '54)

Lutzke, Vance, Water & Sewer Maint. Supervisor, 641 S. Water St., Saginaw, Mich. (July '54) *D*

Marshall, Bert K.; *see* Schwartz Co.

Matthews, Willard, Constr. Engr., L. B. McKinney Co., 728 S.E. Union Ave., Portland, Ore. (July '54) *PD*

(Continued on page 96 P&R)

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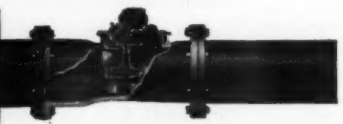

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McMorrow, Thomas; *see* Contra Costa County (Calif.) Health Dept.

Meykadeh, G. A.; *see* Tehran (Iran) Water Supply Organization

Midlothian, Village of, John Nugent, Supt. of Public Works, 14801 S. Crawford, Midlothian, Ill. (Corp. M. July '54) *PD*

Moranda, Walter B.; *see* Port Hueneme (Calif.) Water Dept.

Morris, George E., Civ. & San. Engr., Utilities Sec., Maint. Unit, Directorate of Installations, US Air Force, Hq. Tactical Air Command, Langley Air Force Base, Va. (July '54) *MRPD*

Nasor, Lee M., Office Engr., Montgomery County San. Dept., 127 N. Perry St., Dayton, Ohio (July '54) *MR*

Nelson, Eugene D., Civ. Eng. Asst., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (July '54) *D*

North Vancouver, Corp. of the Dist. of, A. H. Ashworth, Munic. Engr., 171 W. Esplanade, North Vancouver, B.C. (Munic. Sv. Sub. July '54) *M*

Nugent, John; *see* Midlothian (Ill.)

O'Connor, William L.; *see* Schenectady (N.Y.) Health Dept.

Peters, H. E., Board of Public Affairs, Oak Harbor, Ohio (July '54)

Port Hueneme Water Dept., Walter B. Moranda, Supt., Box 298, Port Hueneme, Calif. (Corp. M. July '54) *MRD*

Price, Harry S., Jr., Exec. Vice-Pres., Price Brothers Co., 1932 Monument Ave., Dayton, Ohio (July '54) *D*

Proctor, Robert E., San. Engr., Porter, Urquhart & Beavin, 3568 W. 3rd St., Los Angeles 5, Calif. (July '54) *PD*

Putnicki, George J., Asst. Sr. Engr., Water Dept., Dallas, Tex. (July '54)

Rapid City Water Dept., L. P. Steiling, Supt., 829 St. Joseph St., Rapid City, S.D. (Corp. M. July '54) *MRP*

Reis, M. J., Reis & Chandler, Inc., 30 Vesey St., New York 7, N.Y. (July '54)

Riggle, Richard D., Supt., Water Works, Roachdale Water Co., Roachdale, Ind. (July '54) *MP*

Ristaino, Antonio J., Chem. Engr., US Navy Eng. Experiment Sta., Annapolis, Md. (July '54) *P*

Saltmarsh, Ralph D., Sales Repr., Price Brothers Co., 1932 E. Monument Ave., Dayton, Ohio (July '54) *D*

Schenectady Health Dept., William L. O'Connor, Public Health Engr., City Hall, Schenectady, N.Y. (Munic. Sv. Sub. July '54) *MRPD*

Schiller, Henry M., Assoc. Engr., Water Power & Control Com., 110 State St., Albany 7, N.Y. (July '54)

Schneider, Robert J., Operator, Indian Hill Water Works, 8100 Given Rd., Cincinnati 27, Ohio (July '54)

Schrader, George P., Jr., Design Engr., Utilities Group, Dept. of Design & Constr., Carbide & Carbon Chemicals Co., South Charleston, W.Va. (July '54) *PD*

Schwartz Co., Inc., Bert K. Marshall, Sales Mgr., 1600 E. 11th St., El Paso, Tex. (Assoc. M. July '54)

Scott, W. E., 887 Gaston St., S.W., Atlanta, Ga. (July '54)

Sharman, James P., Chief Engr., Lakewood Water & Power Co., 2965 E. Carson St., Lakewood 8, Calif. (July '54) *RPD*

Sheridan, J. Rodger, Pres. & Gen. Mgr., Northwest Filter Co., 122 Elliott Ave., W., Seattle 99, Wash. (July '54) *P*

Simmons, K. Ross, Town Engr., Georgetown, Ont. (July '54)

Smith, Park H., 1st Asst. Fire Chief, 151 Martin St., Birmingham, Mich. (July '54) *MRD*

Smith, Willard B., Field Supt., Ector Water Co., 417 Midland Tower, Midland, Tex. (July '54)

Stansberry, Elmer F., Civ. Engr., Price Brothers Co., 1932 E. Monument Ave., Dayton, Ohio (July '54) *R*

Steiling, L. P.; *see* Rapid City (S.D.) Water Dept.

Tehran Water Supply Organization, G. A. Meykadeh, Mng. Director, Box 5, Tehran, Iran (Corp. M. July '54) *MRP*

Temperley, Tom G., Chemist, Distillation Plant, Box 18, Kuwait, Persian Gulf (July '54) *RPD*

Thompson, William Y., Civ. Engr., Board of Water Supply, County of Hawaii, Hilo, Hawaii (July '54) *PD*

Toronto, Municipality of Metropolitan, Dept. of Works, L. B. Allan, Comr., 11 King St. W., Toronto 1, Ont. (Corp. M. July '54) *MRPD*

Trumbull, H. Jay, Pres., Florida Water Conditioning Co., Box 448, Atlantic Beach, Fla. (July '54) *P*

Underwood, W. C.; *see* Goodyear Atomic Corp.

Victor, Michael, Jr., Asst. Supt., Board of Water Supply, County of Hawaii, Hilo, Hawaii (July '54) *PD*

Weeks, R. Kenneth, Partner, Causey & Weeks, 5205½ E. Sewells Point Rd., Norfolk 13, Va. (July '54) *RPD*

West Bridgewater Board of Water Comrs., Gordon A. McDonald, Secy., Town Hall, West Bridgewater, Mass. (Munic. Sv. Sub. July '54) *MD*

White, John Parker, Vice-Pres. & Sales Mgr., Thread-Ezy Mfg. Co., Coronna, Mich. (July '54) *PD*

Wicklund, Glenn W., Sales Repr., The Dorr Co., 2631 University Ave., St. Paul 14, Minn. (July '54) *MP*

Winter, Carl W.; *see* New Miami (Ohio) Board of Public Affairs

Woehrle, Ernest A., Design Engr., Carbide & Carbon Chemicals Co., South Charleston, W.Va. (July '54) *PD*

Wurtemberger, Fred J., San. Engr., Glace & Glace, 1001 N. Front St., Harrisburg, Pa. (July '54) *MRPD*

Young, Carl E., Sr. Operator, Water Filtration Plant, Water Dept., San Luis Obispo, Calif. (July '54) *MPD*

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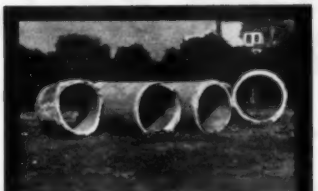
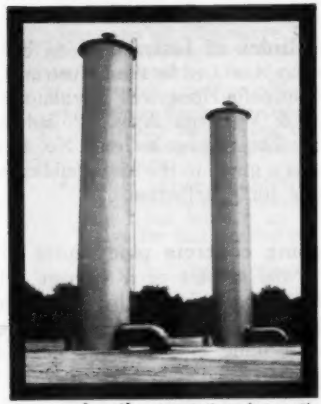


Sections removed from 27 year old Riverside pipeline to accommodate new pumping system.

Unretouched photo of pipe section after 27 years in the ground. Note smooth interior wall.



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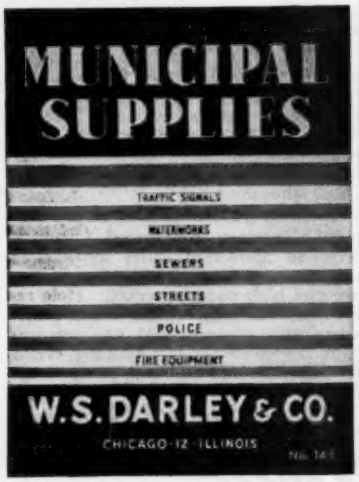

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Pipe marking tags printed on pressure-sensitive tape is the subject of a bulletin obtainable from North Shore Nameplate Inc., Bank of Manhattan Bldg., Bayside, L.I. A large number of printed labels are carried as stock items.

Redwood for flocculation paddles, settling scrapers, and other water treatment uses is the subject of a feature in the Summer 1954 edition of *Redwood News*, distributed by California Redwood Assn., 576 Sacramento St., San Francisco 11, Calif.

An "Index of Literature" on instrumentation is offered by the Industrial Div. of Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa. The 12-page bulletin, No. 100-C, serves as a guide to the M-H publications available for distribution.

Tapping concrete pipe under pressure is the subject of a 12-page, illustrated handbook issued by Price Bros. Co., 1932 E. Monument Ave., Dayton 1, Ohio. Making taps in both small and large prestressed concrete pipe is described.

The Dowell acidizing service for water wells is described in a folder available from the company, Dowell Inc., Box 536, Tulsa 1, Okla.

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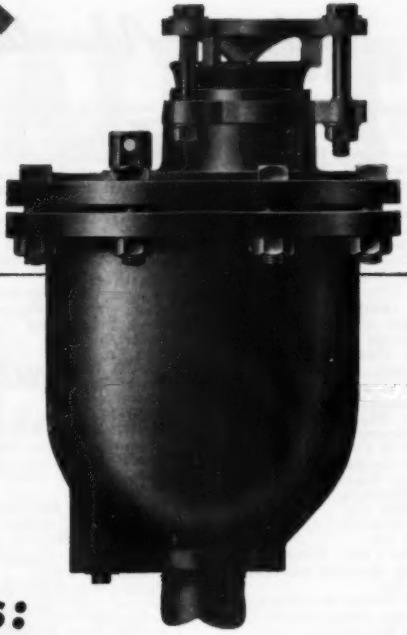

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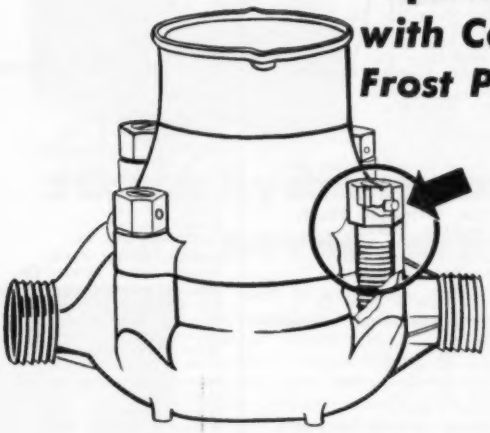

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United States Pipe & Foundry Co.
Universal Concrete Pipe Co.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Universal Concrete Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutters
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
Reed Mfg. Co.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe, Steel:
American Locomotive Co.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Morse Bros. Mchy. Co.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc.
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Infilco Inc.
Wallace & Tiernan Inc.

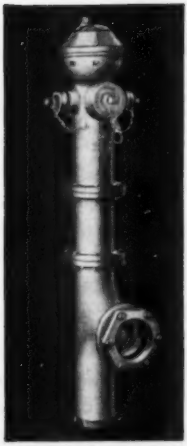
Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Proud "city fathers" must look to the future, too!

IOWA hydrants and valves are never "orphans"!



No need to worry about the future of your city's water system when you choose *Iowa*. You know you're buying a reliable product from a reliable firm and that there will always be replacement parts, when and as needed. What you may not know, though, is this . . . *Iowa* hydrants are easily and economically serviced—even by new employees without special training.

Below are additional facts to keep in mind when you plan to expand or replace any part of your city water works.

IOWA HYDRANTS

Provide full, truly unrestricted water way.

Open *with* the pressure for faster water delivery.

Close *against* the pressure to eliminate water hammer, provide flushing action.

Assure positive drainage.

Are available for any type of connection.

All working parts removable through top—no digging or special tools required.

Meet all A.W.W.A. specifications.

IOWA GATE VALVES

Double disc, parallel seat.

Positive wedging action for efficient, no-leak closing.

Gates hung loosely from stem nut—no binding.

Rugged, time-proved design means long life, low service costs.

Available with bell, flange, or mechanical joint connections to fit any existing or planned installation.

Meet all A.W.W.A. specifications.

The best insurance policy is the order that specifies IOWA!

IOWA VALVE COMPANY

A Subsidiary of James B. Clow & Sons

201-299 NORTH TALMAN AVENUE

CHICAGO 80, ILLINOIS

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
General Filter Co.
Permutit Co.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Sodium Silicate
Philadelphia Quartz Co.

Softeners:
Belco Industrial Equipment Div.
Cochrane Corp.
Dorr Co.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp.
General Filter Co.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Taste and Odor Removal:
Cochrane Corp.
General Filter Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Backflow Engineering & Equipment Co.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
DeZurik Shower Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
DeZurik Shower Co.
Foster Eng. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Gulf States Asphalt Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Well Drilling Contractors:
Layne & Bowler, Inc.

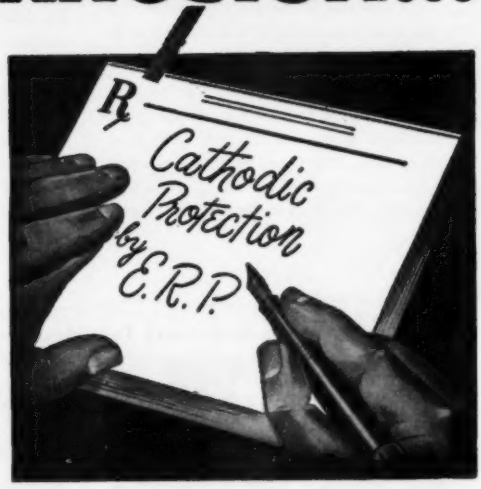
Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.

℞ FOR CORROSION...



You don't need a specialist to *recognize* Corrosion. But you do need one to treat it successfully. The skill required to achieve complete corrosion control comes only from the knowledge and experience gained through years of practical application.

Recognition of that fact is one reason more and more people are turning to E.R.P. for assistance on corrosion problems—one reason that thousands of buried or submerged steel structures of all types have been successfully protected against corrosion by E.R.P. engineers. Corrosion specialists *for over 17 years*, these men are highly trained and well equipped to help you with *your* corrosion problem. Write for full information today.

COMPLETE CATHODIC PROTECTION SERVICE • DESIGN ENGINEERING MAINTENANCE INSTALLATION EQUIPMENT

ELECTRO RUST-PROOFING CORP. (N. J.)
BELLEVILLE 9, NEW JERSEY
REPRESENTED IN PRINCIPAL CITIES IN THE UNITED STATES

-E27

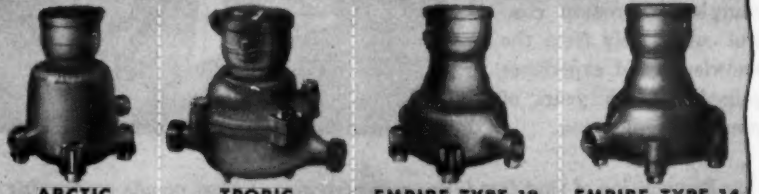
HOW MUCH did your old meters cost you today?

The meters you bought 20 or more years ago were the best you could buy *then.* But today, because of the accomplishments of Rockwell's engineering and research staff, their performance is dated.

Consider the matter of accuracy at low flow rates. Meters of 20 years ago were designed and built to measure only 90% of the flow at ¼ gpm. These same meters even when repaired, cannot be expected to exceed this accuracy. New Rockwell meters easily measure 95% of the ¼ gpm flow and can readily be renewed to duplicate this performance.

We believe you owe it to your city or water company to know what's new and better in water meters—and what old out-dated meters are costing you. Let the Rockwell representative show you proof that a carefully planned program of old meter replacement will materially increase your revenue and cut meter maintenance costs so drastically that it will more than pay for itself.

Rockwell Modern Meters For Modern Measurement Needs



ARCTIC	TROPIC	EMPIRE TYPE 12	EMPIRE TYPE 14
Disc Type	Disc Type	Piston Type	Piston Type

The Symbol for Service, Quality and Performance in Water Meters

ROCKWELL MANUFACTURING COMPANY

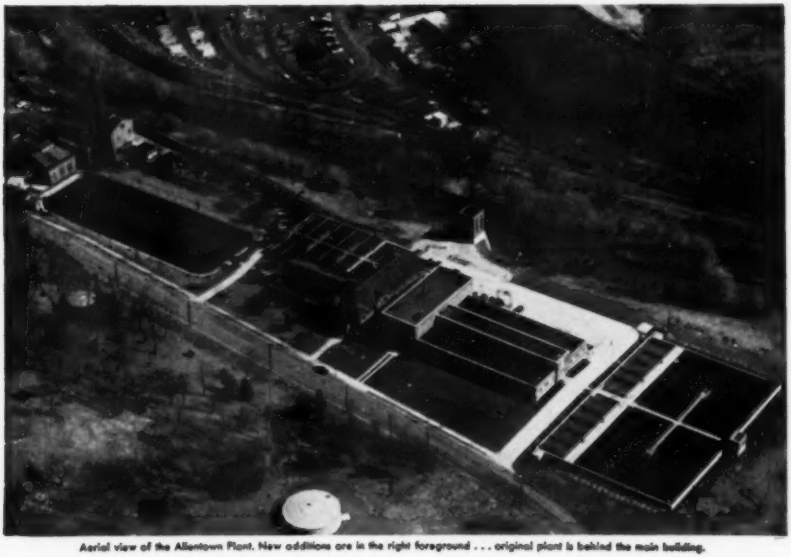
PITTSBURGH 8, PA. Atlanta Boston Chicago Houston
Los Angeles N. Kansas City New York Philadelphia
Pittsburgh San Francisco Seattle Tulsa

In Canada: Peacock Brothers Limited

in water treatment problems...

you won't find identical twins

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



Aerial view of the Allentown Plant. New additions are in the right foreground . . . original plant is behind the main building.

Allentown, Pennsylvania MODERNIZES EXISTING PLANT... ADDS NEW PLANT...

Faced with an expanding population and a badly overloaded water treatment plant, Allentown, Pa. called in Morris Knowles, Inc. of Pittsburgh, Pa. to design treatment facilities for 30 MGD. The Engineers first surveyed the existing facilities and found that effective use could be made of two rectangular plain sedimentation basins. Two Dorrco Flocculators, each with three rows of paddles, were installed at the head end of each basin in the twenty-five-year-old 10 MGD plant, thus greatly increasing the efficiency to prepare the water for settling and filtering. For the additional 20 MGD capacity the Engineers specified two more sets of Dorrco Flocculators to operate in combination with two SZ-7 Dorr Squarex Clarifiers each 110 ft. square. Two Dorrco Flash Mixers were also installed as well as additional filter capacity.

If you'd like more information on the complete line of Dorr water treatment equipment, write for Bulletin No. 9141 to The Dorr Company, Stamford, Connecticut, or in Canada, 26 St. Clair Avenue E., Toronto 5.

Every day, nearly 8 billion gallons of water are treated by Dorr equipment.

FIFTY YEARS 1904-1954

Better tools TODAY to meet tomorrow's demand

DORR

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

THE DORR COMPANY • ENGINEERS • STAMFORD, CONN.
Offices, Associated Companies or Representatives in principal cities of the world.

LEADITE

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

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Girard Trust Co. Bldg. Philadelphia, Pa.